ADA018237

AD

TECHNICAL REPORT
75-104-CEMEL

A HUMAN FACTORS EVALUATION OF COLD WEATHER HEADGEAR

by

John M. Lockhart

and

Carolyn K. Bensel

Approved for public release;
distribution unlimited.

October 1975

UNITED STATES ARMY
NATICK DEVELOPMENT CENTER
NATICK, MASSACHUSETTS 01760

Clothing, Equipment & Materials Engineering Laboratory
CE&MEL-150

Approved for public release; distribution unlimited.

Citation of trade names in this report does not constitute an official indorsement or approval of the use of such items.

Destroy this report when no longer needed. Do not return it to the originator.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

(18) NDC

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: (19) TR 75-104-CEMEL	2. GOVT ACCESSION NO. (9)
3. RECIPIENT'S CATALOG NUMBER: Technical Rept.	
4. TITLE (and Subtitle): (6) A HUMAN FACTORS EVALUATION OF COLD WEATHER HEADGEAR	5. TYPE OF REPORT & PERIOD COVERED
6. PERFORMING ORG. REPORT NUMBER: (14) CEMEL-150	
7. AUTHOR(s): (10) John M. Lockhart and Carolyn K. Bensel	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Clothing, Equipment and Materials Engineering Laboratory, US Army Natick Development Center, Natick, MA 01760	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: IT762716AH70-02
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Natick Development Center, Natick, MA 01760	12. REPORT DATE: (11) October 1975 (12)
	13. NUMBER OF PAGES: 97 102p.
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): (16) DH-I-T-762716-AH-70 (17) I-T-762716-AH-70	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

HEADGEAR	COLD WEATHER HEADGEAR	COLD REGIONS
CLOTHING	COLD WEATHER	MOISTURE
PARKAS	COLD-WET HEADGEAR	COLD-DRY ENVIRONMENT
PROTECTIVE CLOTHING	COLD-WET CLIMATES	COMFORT

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A human factors evaluation of the standard and experimental insulating caps and of the standard cold weather headgear system (cap plus arctic hood and fur ruff with and without the cold weather face mask) and the experimental cold weather headgear system (cap, face piece, and integrating collar) was made in a series of investigations: a visual field investigation, a personal and equipment compatibility test, and cold-wet and cold-dry chamber tests. Results indicated (a) superiority of the experimental system over the standard system only with respect to the

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

408902 SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) 1/2

20. Abstract (cont'd)

size of the field of vision and rotation head movements and (b) standard system superiority over the experimental system for donning speed, ventral-dorsal head movements and thermal protection, comfort, and preference during cold-dry exposure.

TECHNICAL REPORT

75–104–CEMEL

A HUMAN FACTORS EVALUATION OF COLD WEATHER HEADGEAR

October 1975

Clothing, Equipment, and Materials Engineering Laboratory
US Army Natick Development Center
Natick, Mass. 01760

PREFACE

The study reported here was conducted by the Human Factors Group, CE&MEL. This work was carried on as part of Task 02 under Project Number 1T762716AH70, Human Factors Analysis and Design Guidance in Support of Materiel Research and Development.

The authors wish to express their appreciation to Ms Kathryn L. Murtagh for her assistance in the collection of the data and to SP5 John M. Bassett and SP5 Ronald Cotta for their assistance with the data analysis.

TABLE OF CONTENTS

PRECEDING PAGE BLANK-NOT FILMED

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

LIST OF FIGURES

LIST OF FIGURES (cont'd)

LIST OF TABLES

LIST OF TABLES

A HUMAN FACTORS EVALUATION OF COLD WEATHER HEADGEAR

INTRODUCTION

A hood with fur ruff and an insulating cap are worn in conjunction with a parka as the headgear comprising the standard Army cold-dry uniform. The cap, which also serves as the standard cold-wet headgear, is made of cotton and nylon oxford cloth and has nylon knit, fleece-lined earlaps and neck protector with hook and pile closure at the throat, elastic nape strap, and a nylon stretch panel. An adjustable forehead flap or brim provides sinus protection, and buttonholes in each side of the front earlap provide access for the helmet chin strap (Figure 1). The cap is available in six hat sizes.

The hood provides protective covering for the head, face, throat, and back of neck. It also is made of cotton and nylon oxford cloth and has a wool and nylon fleece-lined crown and inner skirt. A wire around the circumference of the hood brim allows adjustment and manipulation of the area covered by the brim. A drawcord is also provided for additional adjustments. The hood has a hook and pile front closure with a single button. Buttonholes on the inner skirt and buttons on the underside of the storm curtain are used to attach the hood to the parka (Figure 2).

It has been maintained that the funnel shape of the hood enhances protection against frostbite by entrapping warm air around the wearer's face and that this air provides a buffer against low ambient temperatures. This claim was investigated by Veghte (Reference 1) who exposed five men outfitted in standard Air Force arctic clothing to an ambient temperature of −62°C and a windspeed of less than 26 m/min for 40 to 50 min. The clothing included a parka and hood with fur ruff similar in design to the equivalent standard Army items. During exposure, the subjects stood at rest for 30 min, walked for 12 min, exercised strenuously by running in place for 3 min, and stood at rest again for 5 min. Body temperatures were monitored 6 mm inside the nasal vestibule and on the side of the nose. Ten other thermocouples were placed on a narrow strip of cardboard extending through the hood opening at intervals of 25 mm from the cheek for a distance of 250 mm. The opening of the hood was 130 mm away from the cheek. Temperatures were recorded from each thermocouple once per 5 min during the entire exposure period.

The coldest inspired air temperature was 11°C and the coldest skin temperature on the side of the nose was 7°C. There was no appreciable quantity of warm air trapped within the hood. A rapid turnover occured due to the expulsive nature of expiration and convective air movement. However, even while the subjects were standing at rest, movement of warm air up through the clothing and out the hood opening maintained air temperatures above −25°C at a distance of 25 mm from the cheek, while, at distances of 75 mm or more from the cheek, temperatures approached ambient levels. The thickness and temperature of the warm air layer increased during exercise. Therefore, although Veghte (Reference 1) did not find any appreciable pooling of warm air within the funnel

of the hood, warm air from the body did pass by the face and out the hood opening keeping temperatures close to the face above the low ambient level. The hood with its front opening thus served to direct the path of the warm air such that it passed in the area of the face as it was expelled to the environment.

The fur ruff strip, which is attached to the underside of the hood's quilted brim, is provided to protect the face from strong and freezing winds by deflecting the windstream. In addition, the fur is thought to decrease the speed with which the warm air from the body is dissipated into the environment (Reference 2). In performing this latter function, the ruff may accumulate moisture in the form of frost or ice, and such formations are believed to interfere with the ruff's protective function. Therefore, an important property of a fur ruff is the ease of shedding of ice and frost (Reference 2).

In spite of its role in maintaining head skin temperatures, certain undesirable characteristics of the parka hood with fur ruff have been identified. For example, the hood restricts the wearer's visual field, the fur of the ruff may irritate the skin, and the multiple layers of material degrade auditory acuity (References 2 and 3). In addition, noises are caused by the friction of the cold-dry headgear components as the wearer moves his head which, though heard only by the wearer, may mask his perception of external sounds and noises (Reference 4). Attempts have been made over the years to modify or replace the hood and ruff in order to alleviate some of these problems while maintaining the level of thermal protection afforded by the standard headgear.

One early modification involved replacement of the fur ruff with a knitted wool strip. In addition, an elongated, sweater-type neck closure was put on the hood (Reference 3). It should be mentioned that these modifications were made to the hood which was the Army standard in 1945 and which was not as deep as the present standard. Four men were exposed to an ambient temperature of $-45.5^{\circ}C$ with windspeeds ranging from 1.56 to 5.36 m/sec while wearing the standard and the test hoods. No skin temperatures were recorded. Instead, the men were asked to compare the comfort of the two hoods. It was found that the standard restricted the field of vision to a greater extent than did the test hood and the fur caused skin irritation. However, the standard fit a wider range of head sizes and provided greater protection from the wind (Reference 3). Because of these results, work on this modified hood was terminated.

In a more recent effort, a study was done in which the hood was replaced by a balaclava-type helmet and the parka was modified by the addition of a standup collar with alpaca facing (Reference 5). The standard insulating cap was worn under the balaclava helmet. This headgear configuration was tested against the standard consisting of the insultating cap and hood with fur ruff. The standard was found to be superior in thermal protection and frost removal characteristics (Reference 5).

The latest activities in cold weather headgear design were directed toward the development of a system which would provide adequate thermal protection under cold-dry conditions while being less bulky and confining than the present standard items. This effort culminated in development of a prototype consisting of three elements: an insulating cap, a face piece, and an integrating collar (Figure 3). This system was designed to interface with the standard field jacket and the parka and to replace the present insulating cap and hood with fur ruff.

The experimental cap (Figure 4) is similar in design to the standard, but has no brim and is made of helenca, open-cell urethane foam, and cotton jersey laminate. The neck portion of the experimental cap is longer than that on the standard cap and fits under the collar of the field jacket. The experimental cap material is quite elastic and the cap was developed to make use of the elasticity so that a single size would accommodate the fiftieth to ninety-fifth percentile of head dimensions of the US Army male population (Reference 6). There are hook fastener tapes on the outer surface of the chin flaps which are used to secure the flaps together. Strips of hook fastener tape are also affixed to the sides of the cap in the ear area to provide for attachement of the face covering. A laminate of pile material and helenca forms a flap around the external surface of the cap. The pile material on the inner surface of the flap interfaces with the hook material on the outer surface of the integrating collar to hold the latter in place (Reference 6).

The cape-like integrating collar is to serve as a barrier against cold air and wind which might otherwise pass into the neck of the field jacket or parka. The collar's hook material, which mates with the insulating cap, lies against the outer surface of the field jacket or parka collar. The integrating collar is made of helenca, urethane foam, and cotton jersey laminate and uses hook and pile fasteners as a closure in the throat area (Reference 6).

The semicircular face piece is made of pile material bonded to helenca. An aluminum stiffener bar at the top of the face covering is designed to be formed to the facial contours and to pass over the bony ridge of the nose and under the eyes with an overlap onto the ear area of the insulating cap where it is attached. The inner surface of the stiffener bar is padded with polyurethane foam. The excess material of the face piece can be folded over to form a pocket in the oronasal area using hook and pile tape attached to the covering. The edges of the covering can also be affixed to the hook material of the insulating cap to completely enclose the lower face area (Reference 6).

The experimental insulating cap was designed to be used alone as a replacement for the standard cap and, when augmented by the integrating collar and the face piece, as the headgear for cold-dry conditions. Details of the design and fabrication of the experimental items are presented in Reference 6. In order to assess the utility of this headgear system, a human factors investigation was initiated. The experimental and the standard headgear systems were evaluated in three series of tests:

I. Visual field investigation
II. Pre-chamber testing
III. Arctic chamber testing

The methods, results, and discussions related to each of these tests are presented in this report.

I. Visual Field Investigation

Purpose — The purpose of conducting this test was to determine the limits of the visual field for each cold weather headgear system being evaluated. The criterion for the experimental system in this test is that it shall not restrict field of vision to a degree greater than current field clothing and equipment.

Subjects — Five test subjects were selected at random from the Climatic Research Laboratory Test Subject Platoon with the restriction that the subject did not require corrective lenses.

Procedure — Measurements of the visual field were made on a Bausch & Lomb Projection Perimeter under a fixated eye condition. The subject fixated one eye on a central target, while the other eye was covered by an opaque patch, and detected a target moving in from the periphery. The target to be detected, under normal room illumination, was a white, circular light with a diameter of 5 mm projected 33 cm from the subject's eye and subtending a visual angle of 0.87°. The measurements were made monocularly for each eye for each of eight areas of visual field: temporal, supra-temporal, superior, supra-nasal, nasal, infero-nasal, inferior, and infero-temporal.

The visual field of each subject was measured under the following conditions: no headgear, standard insulating cap, experimental insulating cap, standard insulating cap with cold weather face mask, and experimental insulating cap with face piece and integrating collar. The subjects wore the parka only with those conditions involving the cold weather face mask or the face piece and integrating collar. No other arctic equipment, goggles, or glasses were worn during the test.

Results and Discussion — Figures 5 and 6 are plots of the mean visual field for the right eye and the left eye, respectively, under the conditions of no headgear, standard insulating cap, and experimental insulating cap. The means represent the data for all five subjects. In Figure 7, the measures from each eye were combined (reversing portions of the visual field for the left eye, as required) to obtain one mean value for each of the eight areas of the visual field.

The only restrictions which occurred with either cap were in the superior regions of the field. This restriction was greater with the experimental cap than with the standard cap in the supra-nasal region for the right eye. The slight restrictions in the superior regions resulted from the folded back peak brim of the standard cap and the lower brow portion of the experimental cap.

Figures 8 and 9 are plots of the mean visual field for the right eye and the left eye, respectively, under the conditions of no headgear, standard cap with cold weather face mask, and experimental cap with face piece and integrating collar. Again, the means represent the data for five subjects and the combined measures for both eyes are presented in Figure 10.

While both headgear systems restricted superior regions of the visual field, the combination of the standard cap and face mask resulted in restriction of the inferior and infero-nasal portions of the visual field as well, due apparently to the presence of the oro-nasal barrier on the face mask. The wearing of the experimental cap, face piece, and collar system did not restrict these portions of the visual field.

In general, the experimental system meets the criterion of not restricting the field of vision to a greater degree than the standard headgear system. Furthermore, the experimental system resulted in a much improved visual field when compared with that for the standard cap plus arctic face mask.

II. Pre-Chamber Testing (Personal and Equipment Compatibility)

Purpose – The purpose of this test was to evaluate four cold weather headgear systems with regard to ease of donning and doffing, compatibility with infantry helmet, ability of the wearer to perform bodily functions such as drinking, spitting, etc., compatibility with weapon operation and standard arctic clothing, and the ability to perform two standard head movements. The criteria against which the systems are being evaluated are the following: 1) the design and construction of the cold weather headgear shall be such that it is compatible with the use of weapons and equipment; 2) the headgear shall be designed so as to permit maximum ease of donning and doffing; 3) the system shall permit simple adjustment or adaptations without assistance to various levels of physical activity, body functions, and environmental conditions.

Subjects – Eight test subjects who had been selected at random from the CRL Test Subject Platoon for participation in the Arctic Chamber Testing also participated in the Pre-Chamber Testing.

Procedure – Each subject was given a parka with liner and either the hood with fur ruff and standard cap or the experimental cap, face piece, and integrating collar. Standardized instructions (Appendix A) were read to the subject while he attached the standard or the experimental cold weather headgear systems to the parka and donned each system. The subject was then permitted to familiarize himself with the donning operation and the fit of the headgear system was checked.

While wearing the field jacket with liner and either of the caps with earflaps down and fastened in front of the chin, the subject was asked to drink water from a glass and was permitted to smoke. The subject was asked if he experienced any difficulty drinking the water and if he would find it difficult to blow his nose or eat while wearing the various cold weather headgear systems.

In order to evaluate weapon compatibility with the headgear systems, each subject sighted a 3.7 cm target at 9 m using a M-16 rifle. The subject lay prone. On signal, he picked up the rifle, sighted the target, and reported pulling the trigger. The subject's "time to fire" was measured by recording the time interval between the "Go" signal and the verbal report of having fired the weapon. Each subject received three trials under the following clothing conditions: Cold-wet (fatigues, field jacket with liner and either the standard or the experimental insulating cap); Cold-dry (fatigues, field jacket with liner, parka with liner, and either the standard cap and arctic hood with fur ruff, or the experimental cap with face piece and integrating collar).

After the weapon compatibility test, the subject, still equipped with the cold-dry uniform, was given standard Army goggles (Goggles, Sun, Wind, Dust) and was asked to remove the headgear systems. Then, wearing the arctic mittens with liner, the subjects

donned the goggles and one of the two cold weather headgear systems. The time to complete the donning was recorded. The donning operation was repeated two more times. Then the subject removed the arctic mittens, put on the wool trigger finger mitten inserts, and donned one of the two cold weather headgear systems and goggles for three trials. For the standard cap, the donning operation consisted of putting on the cap, fastening the earflaps in front of the chin, putting on the goggles, pulling the hood over the head and fastening the fur ruff under the chin. The donning operation for the experimental system consisted of putting on the cap and integrating collar together, tucking the inner neck piece of the cap under the parka and field jacket collars, smoothing the collar down, fastening the cap and collar under the chin, and putting on the goggles.

After the donning operation, each subject completed four trials each on two head movement tasks (ventral-dorsal head movement and head rotation) while wearing first the cold-wet uniform and then the cold-dry uniform. For the ventral-dorsal head movement task, the subject sat in a chair with his hands clasped behind the back of the chair. A goniometer was attached to the side of the subject's cap or hood. The subject moved his head as far ventral as possible and the goniometer was set to zero, then the subject moved his head as far dorsal as possible and the angular distance was recorded, in degrees, from the goniometer. The subject completed this task four times and the score analyzed was the mean distance travelled, in degrees, across the four trials. For the head rotation task, the goniometer was attached to the top of the subject's cap or hood. The subject bent at the waist until his back and back of head were parallel to the floor and supported himself by grasping the chair with both hands. Then the subject rotated his head to the left as far as possible; the goniometer was set to zero; the subject rotated his head to the right as far as possible; and the distance travelled, in degrees, was recorded. The head rotation task was performed for four trials under each of two clothing conditions. The head rotation score analyzed was the mean distance travelled, in degrees, across four trials.

After completing the head movement tests, the subjects donned the infantry helmet with liner while wearing the cold-dry uniform and appropriate headgear system. The subjects then completed the pre-chamber testing questionnaire (Appendix B) regarding the tasks performed.

Each of the eight subjects completed the above procedure on two separate days. Each day the subjects wore a different headgear system. The order of presentation of two headgear systems was counterbalanced across days.

Results and Discussion – The data consisted of mean time to fire the rifle, in seconds, for both the cold-wet and cold-dry uniform conditions; mean donning time, in seconds, while the arctic mittens or the trigger-finger mitten wool inserts alone were worn; and mean degrees of ventral-dorsal head movement and head rotation for both clothing

conditions. The above data were analyzed using subject by headgear analysis of variance designs. The remaining data were the subjects' responses to the questionnaire. The tabulated data from this questionnaire are presented in Appendix C.

Familiarization with the Headgear – With one exception, all subjects reported that the instructions for donning both headgear systems were clear (question 1a). One subject reported that the standard headgear system instructions regarding the attachment of the arctic hood to the parka were unclear. The majority of the subjects under each of the headgear conditions reported that headgear fit was comfortable (question 1b). Only one subject reported headgear fit as uncomfortable and this was for the experimental condition. Some difficulty was observed with the fit of the experimental system. The primary source of fitting difficulty was a looseness at the temples resulting in gaps between the skin and cap. On subjects with hat sizes of 7¼ or less, the crown of the experimental headgear was also too large causing the headgear to sit low on the forehead (over the brow) or, if properly positioned on the forehead, high off the top of the head.

Performance of Personal Body Functions – With one exception, the eight subjects reported having no difficulty, while wearing either cap, with taking water from a glass (question 8a), spitting out the water (question 8b), getting the cap wet (question 8c), being able to eat (question 10), and blowing the nose (question 11). One subject reported interference with taking water from a glass while wearing the experimental cap. Only one subject actually tried to blow his nose (question 12), but he offered no additional information.

Of the two subjects who did smoke, neither reported any interference from either cap while smoking (question 9).

Weapon Compatibility – The mean "time to fire" scores were analyzed and the analysis of variance results are presented in Table 1. For the cold-wet uniform condition, the effect of headgear on the "time to fire" score was not significant and the mean score across headgear conditions was 3.45 seconds (Table 2). All eight subjects reported no interference with being able to sight the rifle when the standard cap was worn alone. One subject reported a great deal of interference, one subject reported a little interference, and six subjects reported no interference with being able to sight the rifle when the experimental cap was worn alone (question 6).

For the cold-dry uniform condition, the effect of headgear on the "time to fire" score was again not significant and the mean scores for the standard cap with arctic hood and fur ruff and the experimental cap with face piece and integrating collar were 4.0 and 3.5 seconds, respectively (Table 2). While wearing the standard cap with arctic hood and fur ruff, four subjects reported a little interference and four subjects reported no interference with being able to sight the rifle (question 7). Three of the four subjects for whom the headgear system gave a little interference reported that the fur got in the way of sighting the rifle. While wearing the experimental headgear with face piece and integrating collar, two subjects reported a great deal of interference and six subjects

reported no interference with sighting the rifle (question 7). Of the two subjects who reported a great deal of interference from the experimental headgear system, one subject complained that "the collar got in front of my sighting eye when I raised the rifle to my shoulders" and the other subject reported interference from the cap slipping down in front of his eyes.

Donning the Headgear – Separate Subject by Headgear analyses of variance were conducted on the mean time, in seconds, across three trials to don the headgear system while wearing the arctic mittens or the trigger-finger mitten wool inserts. The analysis of variance summary tables are presented in Table 1. Donning time differed significantly as a function of headgear systems when mittens were worn ($p < .05$) and when wool inserts were worn ($p < .005$). When arctic mittens were worn, the mean times across subjects to don the experimental headgear system and the standard headgear system were 59.3 and 37.4 seconds, respectively (Table 2). Although donning time for both headgear systems was faster when trigger finger inserts were worn, it still required approximately the same amount of additional time to don the experimental system (41.5 seconds) than to don the standard system (18.9 seconds, Table 2).

Principal sources of difficulty which were observed when the subjects donned the standard cold-dry headgear system while wearing arctic mittens were manipulations of the hook and pile fasteners on the hood and correct fastening of the hood at the neck. When the subjects donned the experimental cold-dry headgear system while wearing arctic mittens, the cap was seldom worn correctly with the back of the cap neckpiece inside the parka, the earflaps of the cap became entangled with the integrating collar, and the face piece was either too high or askew. In general, no one donning the experimental system while wearing arctic mittens was prepared for exposure to cold-dry conditions without further adjustments to headgear fit.

When the subjects were asked whether they had any difficulty donning the headgear with arctic mittens (question 2), their responses were somewhat consistent with donning times. While donning the standard system, six of the eight subjects reported some difficulty. The remaining two subjects reported either no difficulty or that it was easy. While donning the experimental system, four subjects reported much difficulty, three subjects reported some difficulty, and one subject reported no difficulty. The responses to the question of how much difficulty they experienced removing the headgear (questions 3) showed only slight differences between the two headgear systems. One subject reported much difficulty removing the experimental headgear and another subject reported that removing the standard headgear was easy.

The major difficulty observed during donning and doffing of the experimental system with wool inserts was that the wool inserts tended to stick to the cap and collar material and to the hook and pile fastener tape. In general, there was a slight tendency for the subjects to report more difficulty donning (question 4) and doffing (question 5) the experimental than the standard system while wearing trigger finger inserts.

Head Movements – In a comparison between the standard insulating cap alone and the experimental insulating cap alone, the experimental headgear resulted in significantly less mean ventral-dorsal head movement (128° compared to 145°) and mean head rotation (125° compared to 145°) than that for the standard headgear (Table 2). Two subjects judged that the standard cap interfered a little with the head movements and three subjects judged that the experimental cap did. Six subjects and five subjects judged the standard and the experimental cap, respectively, as not interfering with the head movements required (question 15).

When the subjects performed the head movement tasks while wearing either the standard or the experimental cold-dry headgear system, mean ventral-dorsal head movement scores for the standard (135°) and for the experimental (128°) headgear system were not significantly different (Table 2). The standard system, however, did result in significantly lower mean head rotation scores (91°) than did the experimental system (119°, Table 2). For the standard cold-dry headgear system, three subjects reported a great deal of interference, one a little interference, and four no interference from the headgear when making the head movements. Six subjects reported a little interference and two reported no interference with making head movements while wearing the experimental headgear system (question 16).

Helmet Compatibility – There were no unfavorable ratings concerning helmet and headgear compatibility for either the standard or the experimental cold-wet or cold-dry headgear systems (questions 13 and 14).

Conclusions (Pre-Chamber Testing) – Pre-chamber testing results indicated little or no differences between the standard and the experimental headgear systems with respect to comfort, rifle aiming, ability to drink, spit and smoke, and ease of eating and blowing the nose. The experimental headgear was inferior to the standard with respect to donning speed while wearing either arctic mittens or wool inserts and to performing ventral-dorsal head movements. The standard cold-weather headgear system was inferior to the experimental system only with regard to performing head rotation movements.

III. Arctic Chamber Testing

Purpose – The purpose was to evaluate the standard and the experimental insulating caps under cold-wet conditions and three cold weather headgear configurations under cold-dry conditions with regard to wearer comfort, degree of protection afforded, and amount of frosting. The criteria against which the systems are being evaluated are the following: 1) the headgear system, when used with the cold-dry uniform, shall protect the wearer's face from cold, wind, and frostbite; 2) configuration and construction of the headgear system shall provide adequate environmental protection to inspire acceptance and confidence during use; 3) the headgear system shall be designed so that it will be capable of being worn with or without goggles; 4) the system shall not restrict breathing to a degree greater than current field clothing and equipment.

Subjects – Eight subjects were selected at random from the CRL Test Subject Platoon. These same subjects also participated in the Pre-Chamber Testing.

Procedure – The eight subjects were divided into two groups of four subjects each. Each group was tested in the arctic chamber for five consecutive days. For the first two days, the subjects wore the standard and the experimental insulating caps during exposure to cold-wet conditions (one hour exposure to a $-6.7°C$ temperature and 4.47 m/sec wind (Windchill = 1075 kg-cal/m^2/hr)). For the next three days, the subjects were exposed to cold-dry conditions (one hour exposure to a $-45.6°C$ temperature and 4.47 m/sec wind (Windchill = 2140 kg-cal/m^2/hr)).

During the two days of cold-wet exposure, the subjects wore winter underwear, wool shirt and trousers, field coat with liner, and field trousers with liner. The subjects also wore white insulated boots, trigger-finger mittens with wool inserts, and the standard insulating cap on one day and the experimental cap on another day. The order of presentation of caps was counterbalanced over days. Half of the subjects in each group wore standard Army goggles (Goggles, Sun, Wind, Dust) and half wore no eyecover.

During the three days of cold-dry exposure, the subjects wore the cold-wet uniform plus parka with liner and arctic trousers with liner. The subjects also wore white insulated boots, arctic mittens, and, on any given day, one of three headgear configurations. The three cold-dry headgear conditions were (1) standard insulating cap and arctic hood with fur ruff, (2) standard insulating cap, cold weather face mask, and arctic hood with fur ruff, and (3) experimental insulating cap, face piece, and integrating collar. The order of presentation of headgear conditions was counterbalanced over days as far as possible. Half of the subjects wore goggles and half wore no eyecover.

While the subjects were getting dressed in either the cold-wet or the cold-dry uniform, a thermocouple harness was attached to each subject. Thermocouples were taped to the forehead, the tip of the nose, the chin, the throat, the back of the neck, and the right

cheek, as well as behind the right ear and below the left eye. Thermocouples were also placed on the right little finger and the right big toe. All temperatures from these thermocouple locations were recorded once per minute using the Kaye Instruments System 8000 digital temperature recorder and were monitored as a safety precaution. Any subject with a skin temperature of 3.9°C or lower was removed from the chamber. Head temperatures from each of the eight locations were analyzed according to separate analyses of variance to determine if there were significant differences in the degree of thermal protection provided by the three cold-dry headgear systems and if the degree of protection was affected by the type of activity, the presence of eye protection, and the duration of cold exposure. The raw data for the temperature analyses were the temperatures at each location at the start of exposure and at five minute intervals.

During one hour of cold exposure, the subjects were tested in groups of four with cold-wet exposure for two days and cold-dry exposure for three days. The procedure within a day was always the same. Each subject sat facing the wind during the initial 15 minutes of cold exposure (Sit I). For the next 30 minutes, he walked on a treadmill at a speed of 1.12 m/sec while facing the wind (Walk). He again sat facing the wind for the final 15 minutes (Sit II). Upon leaving the chamber, the subject filled out a questionnaire. During the two sitting phases, the subject was not permitted to turn his back to the wind. He was allowed, however, to cover his face with his hands and to lower his head. On the final day of cold-wet and cold-dry testing, each subject completed an additional questionnaire. Thus, each subject completed a questionnaire after each cold-wet exposure (Appendix D), after the end of cold-wet testing (Appendix E), after each cold-dry exposure (Appendix G), and after the end of cold-dry testing (Appendix H).

During the chamber tests, observations were made regarding the occurrence of fogging of the eye protective devices, the accumulation of frost on any portion of the headgear, and the effectiveness of any attempts at frost removal.

Results and Discussion

Cold-Wet Testing

Skin Temperature Data for Cold-Wet Environment – Four of the eight subjects were exposed to an environmental temperature of −17.8°C, instead of −6.7°C, on one day of testing. All four subjects were removed from the arctic chamber within the first 17 min of testing because of low facial temperatures. The remaining cold-wet testing was conducted at −6.7°C. Table 3 contains further information on the headgear and eyecover conditions of subjects removed from the chamber because of skin temperatures equal to or lower than 3.9°C, together with the time at which they were removed and the location of the low temperature point. It can be seen that the testing of two subjects at −6.7°C was terminated and that neither of these subjects was wearing goggles. Because of the extensive loss of data during the cold-wet testing, no analyses were conducted of the skin temperature data acquired under this environmental condition. However, mean

temperatures were obtained for each phase (Sit I, Walk, Sit II), headgear condition, and eyecover condition. Each mean includes the data of two or three subjects and was computed from temperatures recorded once per minute throughout each phase. These means are presented in Figures 11 through 18.

The experimental insulating cap, when compared with the standard cap, resulted in higher forehead temperatures (Figure 11) and higher right ear temperatures (Figure 18). However, the standard cap was superior to the experimental with regard to temperatures below the left eye (Figure 16). For the remaining thermocouple locations, the effectiveness of the standard versus the experimental cap varied as a function of the eyecover condition. For the no goggle condition, the standard cap resulted in higher tip of nose (Figure 12), chin (Figure 13), throat (Figure 14), and right cheek (Figure 15) temperatures than did the experimental cap. However, for the goggle condition, tip of nose and back of neck (Figure 17) temperatures and right cheek temperatures, during Sit I and Walk, were higher with the experimental than with the standard cap.

Overall, the impact of goggles on head temperatures varied among thermocouple locations either increasing, decreasing, or not affecting the temperatures obtained with a given type of cap. Temperatures below the left eye were higher for the goggle than for the no goggle condition, regardless of which cap was worn. Therefore, the presence of goggles protected the area below the left eye from the wind. Forehead, tip of nose, and right cheek temperatures were higher when goggles were worn with the experimental cap than when they were not. It is assumed that the goggles improved aspects of fit thereby increasing the protection afforded by the experimental cap. Chin and right ear temperatures and throat temperatures, during Walk and Sit II, were lowered by the addition of goggles to the standard cap. Thus, the wearing of goggles acted to interfere with the protection afforded by the standard cap.

Since it is common to dispense with eyecover in a cold-wet environment, the data acquired from those subjects without goggles may be more relevant to an actual field situation than the findings for those subjects wearing goggles. If this is the case, then the standard cap can, in general, be judged to offer protection of the head area which is as good or better than that provided by the experimental cap. However, if the assumption relating to goggles and fit is reasonable, it may be possible to improve the effectiveness of the experimental cap by improving fit.

Cold-Wet Chamber Observations – During all chamber testing, observations were made regarding the occurrence of fogging of the goggles and the accumulation of frost on any portion of the headgear. At the completion of each testing session, the headgear was also inspected. Under cold-wet conditions (–6.7°C, 4.47 m/sec wind), there was no indication of fog on the goggles or of frost on any portion of the headgear. Upon post-test examination, both the standard and the experimental caps were found to be completely dry.

Cold-Wet, Post-Chamber Questionnaire – The tabulated data from the **Cold-Wet Post-Chamber Questionnaire** (Appendix D) are presented in Appendix F and the following discussion refers to these data by topic area.

The Headgear as a Protective Device (Questions 1–9) – With respect to thermal protection, both caps were judged to be unsuccessful in protecting the face. There were four very cold responses, four cold responses, and eight cool responses across all conditions. The few differences found in the pattern of responses across conditions appear to relate more closely to the presence or absence of goggles than to the two types of cold weather headgear. The ears received the second greatest number of cold responses and, again, the differences in responses across conditions appear to relate most closely to the presence or absence of goggles. Slight differences were found between the two types of headgear regarding the thermal protection of the throat area. There were two cold and one cool response for the experimental cap and three cool responses for the standard cap. The remaining judgments of the throat area were the same for both cap conditions. The back of the neck was judged about equally often as cool, as about the right temperature, and as warm with very little difference between headgear conditions. In general, when a portion of the head was judged as cold, this was reported as occurring during the first sitting period.

Only one subject reported the formation of frost around the face.

Headgear Comfort (Questions 10, 11, and 14) – All subjects felt that neither type of headgear was heavy. The experimental cap was judged as too loose by three subjects. The standard cap was judged as too loose once and as too tight once. The remaining responses indicated that both caps were neither too tight nor too loose.

The range of comfort responses was from very comfortable (three responses) to somewhat uncomfortable (three responses). There was very little difference between the types of headgear in the pattern of comfort responses.

General Comments (Questions 12 and 13) – When asked to specify their special likes about each of the caps, subjects cited both caps for their light weight. In addition, the experimental cap was liked for its warmth (three subjects), and the standard cap was liked for its good fit (three subjects). When asked to specify their dislikes, three subjects reported that the standard cap did not protect parts of the head from the cold, and three subjects disliked the fit of the experimental cap.

Final Overall Rating by the Subjects – When the subjects were asked, on the last day of the Cold-Wet test, which cap they liked best (Appendix E), four subjects chose the standard cap, three subjects chose the experimental cap, and one subject did not respond. Regardless of which cap was preferred, the reasons for liking or disliking a cap were the same. The preferred cap was judged as warmer and the nonpreferred cap was judged as cooler.

Conclusions (Cold-Wet Chamber Testing) – The cold-wet chamber testing of the two types of headgear indicated that the superiority of one cap over the other with respect to higher skin temperatures varied as a function of thermocouple site and the presence or absence of goggles. Positive and negative comments toward the two caps and overall cap preferences were divided about equally.

Cold-Dry Testing

Skin Temperature Data for Cold-Dry Environment – As can be seen in Table 3, four subjects had to be removed from the arctic chamber because of low tip of nose temperatures. Three of these subjects were not wearing eyecover. The skin temperatures recorded during exposure to –45.6°C were subjected to several analyses using as the raw data the temperatures per 5 min intervals. Each of the eight thermocouple placements on the head was analyzed separately.

In order to identify the effects of headgear, eyecover, and time on skin temperature, the data of the first 15 min of exposure (Sit I) to –45.6°C were analyzed using a hierarchical design of the form: Subjects (1–3) by Time (0, 5, 10, 15 min) by Headgear (Standard, Standard with Face Mask, Experimental) within Eyecover Group (None, Goggles). The effects found to be significant, or to approach significance, in these analyses are presented in Table 4. The significant main effect of headgear was analyzed further using the Newman-Keuls multiple comparison test and these results are presented in Table 5. It can be seen in Table 4 that eyecover condition significantly affected skin temperature below the left eye and approached significance for the tip of the nose measure. In both cases, temperatures were higher when goggles were worn than when no eyecover was used. None of the remaining temperature measures were affected by the wearing of eyecover. With the exception of the throat and the back of the neck, head temperatures varied significantly as a function of the type of headgear worn, with the highest temperatures generally occurring when the standard headgear was worn with the cold weather face mask and the lowest when the experimental system was used (Table 5). Of particular interest are those measures in which the standard headgear, worn without the mask, yielded significantly higher temperatures than did the experimental. This was the case for the forehead, the chin, the cheek, and below the left eye. These data indicate that either standard system offered head protection that was generally superior to that provided by the experimental headgear.

The temperatures from below the left eye, the right ear, the forehead, and the tip of the nose decreased significantly over the course of the 15 min sitting phase. For a number of measures, headgear also interacted significantly with time (Table 4). In these cases, the temperature decrease over time was greatest when the experimental headgear was worn. The one exception was the tip of the nose measure, where the greatest temperature decrease occurred with the standard headgear.

Additional analyses were performed on the data from the cold-dry exposure. However, due to the paucity of the data, the temperatures of the subjects without eyecover were not analyzed further. In order to compare skin temperatures during the first and the last 15 min of exposure to −45.6°C, an analysis of variance of the following form was performed on the data for the goggle group: Subjects (1–3) by Phase (Sit I, Sit II) by Headgear (Standard, Standard with Face Mask, Experimental) by Time (0, 5, 10, 15 min). The significant effects and those approaching significance are presented in Table 6. The significant main effect of headgear was analyzed further using the Newman-Keuls multiple comparison test and these results are presented in Table 5.

It was found that the temperatures from the forehead and below the left eye were significantly lower when the experimental headgear was worn than when the standard was used alone or with the cold weather face mask. There were no differences in throat, cheek, neck, or right ear temperatures as a function of headgear. For both the tip of the nose and the chin, the standard worn without the mask did not yield significantly higher temperatures than did the experimental, although the use of the face mask yielded temperatures significantly higher than those obtained when the experimental was used. In general, the differences in head temperatures as a function of headgear were not as extreme in this analysis as they were when the data for Sit I only were analyzed. The Sit I analysis included the No Goggle data. However, the tendency remained for the standard system, worn with or without a face mask, to yield higher head temperatures than did the experimental (Table 5).

The final analysis performed on the cold-dry data involved the 30 min walking phase for those subjects wearing goggles. The analysis was of the form: Subjects (1–3) by Headgear (Standard, Standard with Face Mask, Experimental) by Time (0, 5, 10, 15, 20, 25, 30 min). The significant effects and those approaching significance are presented in Table 7 and the results of subsequent Newman-Keuls analyses are included in Table 5. For the chin, throat, right cheek, back of neck, and right ear, there were no differences among headgear conditions, while, for the forehead and below the left eye, the experimental headgear yielded temperature levels which were significantly lower than those achieved under either of the two remaining conditions. As was the case in the two other analyses, temperatures at the tip of the nose were significantly higher when the standard headgear was worn with the cold weather face mask when it was worn alone or the experimental system was used (Table 5).

In order to further elucidate on the data analyses, the mean head temperatures for each 5 min of the one hour exposure for those subjects wearing goggles are presented in Figures 19 through 26. It can be seen in these figures that head temperatures generally decreased least over the exposure period when the standard headgear was worn with the cold weather face mask and the greatest decreases occurred with the experimental system. The decreases in forehead and right cheek temperatures are particularly extreme (Figs. 19 and 23).

Arctic Chamber Observations – During the one hour exposure to a temperature of –45.6°C, the lenses of the goggles generally began to fog within the first 5 min. By the end of 15 min, a thick layer of frost had formed on the inner surface of the lenses blinding the subjects. The time course of fogging and frosting of the goggles did not vary as a function of the headgear worn. At –45.6°C, frost formed on the eye lashes and brows of subjects without goggles when they wore the experimental headgear. No frost formation around the eyes was noticed when these subjects used the standard system with or without the face mask.

Regarding frost on the headgear itself, the fur ruff of the standard system became frosted, due to exhalation, on that part of the ruff closest to the mouth area. This generally occurred within the first 15 min of exposure to the cold-dry conditions. When the cold weather face mask was worn, frost formed on the exterior of its oronasal portion and not on the fur ruff. Some subjects complained during the walking phase that the face mask frost impeded breathing. This condition was alleviated when the frost was removed with the back of the arctic mitten.

Parts of the experimental headgear also became frosted during testing under cold-dry conditions. Frost became noticeable within 10 min after initiation of testing and continued to increase and spread. It was first obvious around the border of the face piece. The location of the frost varied somewhat as a function of the configuration of the face piece. Some subjects folded the material to form an air passage directed down toward the integrating collar. With this configuration, the frost formed on the collar as well as on the edges and around the mouth area of the face piece. Other subjects manipulated the face piece by attaching its lower border to the hook and pile material of the cap. Expired air then tended to be directed toward the upper edge of the face piece and out toward the ear area of the cap. The frost then formed around the side border and mouth area of the face piece and on the exterior of the cap in the area covering the ears.

After the testing sessions, all headgear was inspected. At the completion of cold-dry exposures, the interior ear area of the experimental cap was often found to be wet due to exterior frost formation. The interior portion of the face piece which was close to the mouth was generally frozen. With the exception of the oronasal portion, the interior of the cold weather face masks was dry, as were the standard caps.

Cold-Dry Post-Chamber Questionnaire – The tabulated data from the **Cold-Dry Post-Chamber Questionnaire** (Appendix G) are presented in Appendix I and the following discussion refers to these data by topic area.

The Headgear as a Protective Device (Questions 1–12) – When asked to judge the effectiveness of the headgear systems as a screen against the wind, the four subjects

wearing goggles rated the standard system with face mask as excellent. The standard system without face mask was rated as excellent by three and good by one. The experimental headgear system was rated as good (two subjects), average (one), and poor (one) as a screen against the wind. The responses of the subjects who did not wear goggles ranged from excellent to poor without any real difference among the headgear systems.

Whether the thermal ratings for the face and, to a more limited extent, the other parts of the head were different across headgear systems depended upon the presence or absence of eyecover. The four subjects who wore goggles rated the face as being very cold (two), cold (one) or cool (one) while wearing the experimental system; as very cold (two), about the right temperature (one), or warm (one) while wearing the standard system without the arctic face mask; and as warm (two) or hot (two) while wearing the standard system with the arctic face mask. In general, the face became cold while sitting, prior to walking on the treadmill.

Judgments from these four subjects who wore goggles regarding thermal protection afforded the ears ranged from cold to warm for the experimental system, from about the right temperature to warm for the standard headgear without the face mask, and from warm to hot for the standard system when worn with the face mask. With one exception, the four subjects wearing goggles rated the back of the neck and the throat area as being either about the right temperature or warm regardless of headgear system. One subject wearing the experimental system rated the throat area as very cold.

Compared to those subjects wearing goggles, the men without eyecover rated the experimental system higher in thermal protection and the standard headgear with face mask lower. However, the thermal protection ratings given by the subjects without goggles did not favor any one of the three headgear conditions as being superior.

Frost was reported forming around the face by all subjects when the experimental system was worn, by five of eight for the standard system without face mask, and by three of eight for the standard system with face mask. Seven of eight subjects reported their faces becoming wet while wearing the experimental system. Three of eight subjects reported their faces becoming wet while wearing either standard system.

Headgear-Goggles Compatibility (Questions 15, 16, and 17) – For both standard conditions, the subjects reported that some portions of the goggles were fogged up (two without face mask, one with face mask) or all portions were fogged up (two without face mask, three with face mask) and that the fogging occurred while sitting, prior to walking on the treadmill. Of these subjects, half felt that the goggles should be worn with the headgear and half felt that they should not. For the experimental condition, one subject reported no fogging and three subjects reported that all portions were fogged

and that the fogging occurred while sitting, prior to walking on the treadmill (two subjects), or while walking (one). Three of four subjects felt that the goggles should be worn with the experimental headgear.

Effects of the Oronasal Portions of the Headgear Systems (Questions 18–23) – Five of the eight subjects reported difficulty breathing while wearing the arctic face mask. The difficulty occurred during the first sitting period (two), during walking (two), and during the second sitting period (one). One subject, wearing the standard system without face mask, reported breathing difficulties during the first sitting period. No subject wearing the experimental system reported any difficulty with breathing.

The greatest problem with moisture, frost, and freezing of the oronasal portion of the systems was reported by the four subjects wearing the experimental system with goggles. The oronasal portion of the face piece was reported to become wet by four and to freeze by three subjects. The frost forming on the area covering the nose and mouth was judged as a lot (three) or a little (one), had to be shed very often (one), occasionally (one), or never (two), and was difficult to shed causing significant discomfort (three subjects). When those subjects who did not wear goggles wore the experimental system, they found that the part of the face piece covering the mouth and nose became wet (three), frozen (one), had some frost (three) which had to be shed seldom (three) or never (one). Shedding was easy and caused significant discomfort (one) or little or no discomfort (two).

When wearing the standard headgear system without the face mask, the area of the ruff covering the nose and mouth was reported as becoming wet by five of six subjects and as freezing by two of six. Four subjects reported the formation of a little frost which required shedding occasionally (one) or seldom (three) and was easy to shed, causing little or no discomfort (three subjects).

When the four subjects equipped with goggles wore the standard system with a face mask, two reported that the oronasal portion of the mask became wet. None reported any freezing or any problems with frost. Three subjects wearing the arctic face mask without goggles reported a lot (one) or a little (two) frost which required shedding very often (one), occasionally (two) or seldom (one) and was shed with difficulty and discomfort (one) or with ease and little or no discomfort (two subjects).

Headgear Comfort (Questions 13, 14, 24, and 27) – No one reported that any of the headgear systems felt very heavy. For the subjects wearing goggles, there was one report of "a little heavy" for each of the two standard systems. For the subjects who did not wear goggles, there were five reports of "a little heavy" across all headgear systems.

One subject reported that the stiffener under the eye holes of the experimental face piece bothered him a lot. Three subjects wearing the arctic face mask reported that the stiffener bothered them a little.

There was only one report of any adverse skin effects. One subject wearing the experimental system reported a rash on the right cheek. However, frostbite was observed on the right cheek of another subject wearing the experimental system.

All four subjects who wore the standard system with face mask and goggles rated it as "very comfortable". Without goggles, the same system was judged as comfortable (two), fairly comfortable (one), or very uncomfortable (one). For the remaining two systems, all comfort categories were utilized with the experimental system receiving somewhat more negative responses – one rating of uncomfortable and two of very uncomfortable..

General Comments (Questions 25 and 26) – When asked what they especially liked, the subjects mentioned the warmth of each headgear system. However, only the experimental system was liked for being lightweight and offering better vision with no interference. When asked to specify their dislikes, the subjects stated that the standard system without face mask did not protect the face well. The standard system with face mask was disliked for interfering with breathing and vision. The experimental system was disliked because of looseness of fit which permitted cold air leaks.

Final Overall Rating by the Subjects – All four subjects who wore goggles rated the standard system with face mask as best, the standard system without face mask as second best, and the experimental system as poorest. The ratings were not quite as consistent for those subjects who did not wear goggles. The standard system with face mask was judged as best by three subjects and as second best by one. The standard system without face mask received one first place, one second place, and two third place votes. The experimental system was rated as second best twice and as poorest twice. Overall, the standard system with face mask was judged as being the best by seven of eight subjects and the experimental system was judged the poorest of the three cold weather headgear systems by six of eight subjects.

Conclusions (Cold-Dry Chamber Testing) – Overall, the standard headgear system with cold weather face mask provided the best thermal protection in terms of skin temperatures and subjective reports. The same system also resulted in fewer problems related to frost formation and was preferred by seven of the eight subjects. The standard headgear without the face mask was rated as the second best system by six of the eight subjects. Compared to the experimental headgear, it yielded somewhat higher skin temperatures, if not higher subjective ratings of thermal comfort, and resulted in fewer problems associated with frost formation. Based on these results, there is very little to recommend the experimental system over either of the two standard systems.

In the present experiment, the exposure condition was a severe one. Use of the cold weather face mask under such conditions may be advisable regardless of the headgear system. In addition, the nondemanding tasks of sitting and walking permitted

the subjects to close the hood and fur ruff almost completely about the face. Since the experimental system was designed to provide greater visual and auditory contact with the environment, a comparison between the experimental and the standard headgear in a situation prohibiting such closure of the hood and ruff may have led to results different than those obtained here.

SUMMARY

1a. The experimental cap met the criterion of not restricting the field of vision to a greater degree than the standard cap.

1b. The experimental cap with face piece and integrating collar resulted in a much improved visual field when compared with that for the standard cap plus cold weather face mask.

2a. Pre-chamber testing indicated little or no differences between the standard and the experimental headgear systems with respect to comfort, rifle aiming, ability to drink, spit, and smoke and ease of eating and blowing the nose.

2b. Pre-chamber testing indicated that the experimental headgear was inferior to the standard with respect to donning speed while wearing either arctic mittens or wool inserts and to performing ventral-dorsal head movements.

2c. Pre-chamber testing indicated that the standard cold-weather headgear system was inferior to the experimental system with regard to performing rotation head movements.

3a. Cold-wet chamber testing indicated no consistent superiority of either cap over the other with respect to thermal protection.

3b. Subjective reports of thermal protection, comfort, and preference did not discriminate between the standard and experimental cap during cold-wet chamber testing.

3c. Cold-dry chamber testing indicated that the standard headgear system with cold weather face mask resulted in the highest skin temperatures. The standard headgear without the face mask yielded somewhat higher skin temperatures compared to the experimental headgear.

3d. Cold-dry chamber testing indicated fewer problems related to frost formation for the standard headgear with face mask than for the other two systems. Frost formation on the collar and on the side of the experimental cap over the ear and cheek was a serious problem and, in one case, was related to frostbite.

3e. The superiority of the standard system over the experimental system with regard to subjective thermal and comfort reports was more consistent for those subjects with eyecover than those without eyecover during cold-dry exposure.

3f. During cold-dry conditions, standard headgear with face mask was preferred by seven of eight subjects. The standard headgear without face mask was rated second by six subjects and the experimental headgear received six least preferred votes.

REFERENCES

1. Veghte, J.H. "Respiratory and Microclimate Temperatures within the Parka Hood in Extreme Cold". Wright-Patterson Air Force Base, Ohio: Aerospace Medical Research Laboratories, 1964. Tech Report AMRL-TDR-64-79.

2. Mizell, L.R., Frishman, D., and Saxon, R. "Development of Non-Critical Substitutes for Wolverine Fur". Natick, Mass.: Quartermaster Research & Development Center, 1956. Textile Series Report 92.

3. Talbott, J.H. "Parka, Field, Pile, Modified Hood Construction". Lawrence, Mass.: Climatic Research Laboratory, 1945. Test Report R-184-44.

4. Shrager, H. and Brandt, H.H. "A Preliminary Study of Head Noises Produced by Friction in Cold Weather Headgear Assemblies". Natick, Mass.: Quartermaster Reseach & Development Center, 1955. Textile Engineering Lab. Report 134.

5. Murdock, J.E. "Engineering Test of Modified Ensemble, Cold-Dry". Fort Lee, Virginia: Quartermaster Field Evaluation Agency, 1959. Tech Report T-124,58048-F.

6. Manglesdorf, D., Goldberg, M., and Santeschi, H. "Prototype Cold Weather Headgear". Natick, Mass.: US Army Natick Labs, 1974. Tech Report 75-42-CE.

Figure 1. View of Army Standard Insulating Cap

Figure 2. View of Army Cold-Dry Standard Headgear Ensemble

Figure 3. View of Experimental Insulating Cap, Face Piece, and Integrating Collar

Figure 4. View of Experimental Insulating Cap

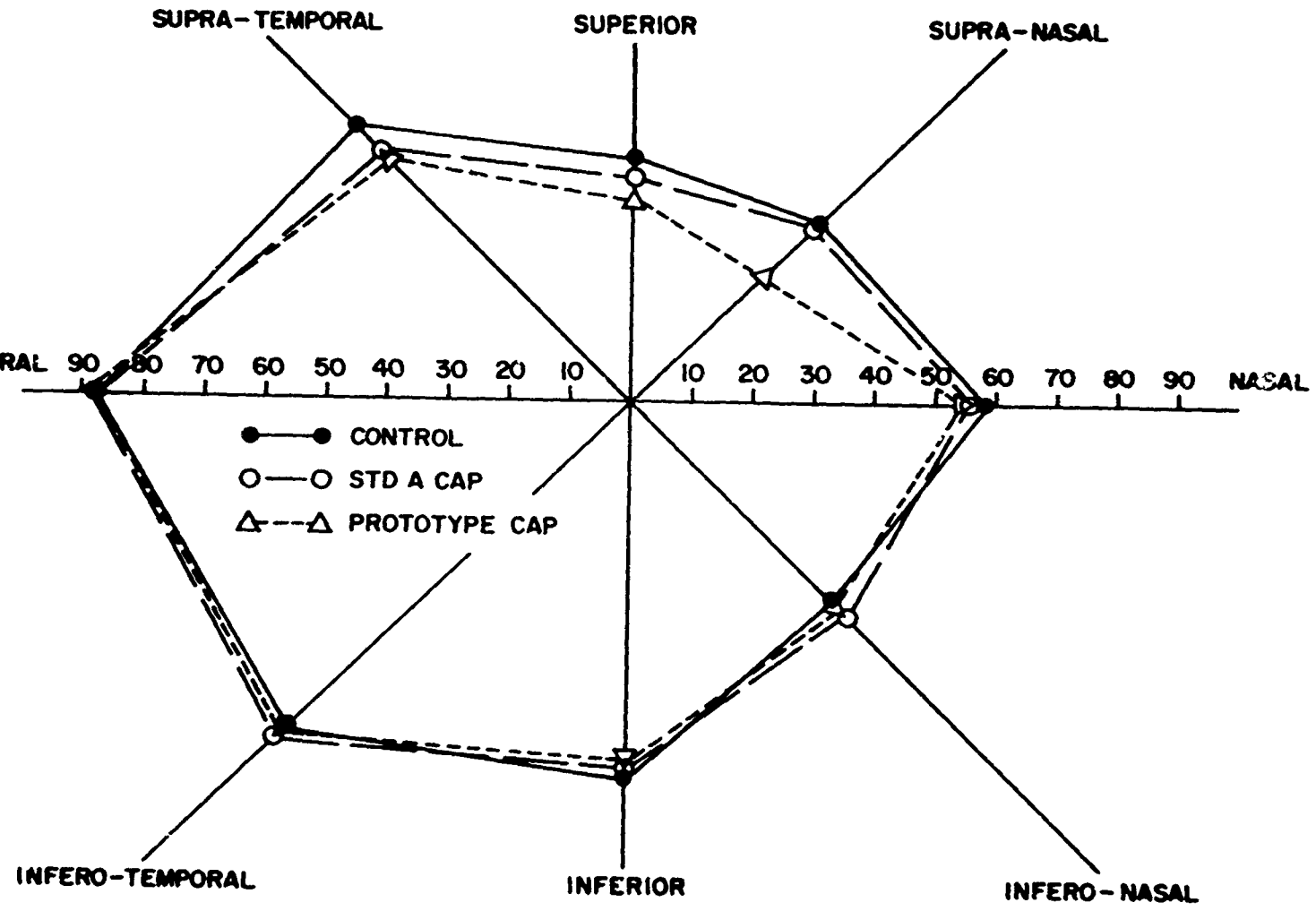

Figure 5. Plot of the Mean Visual Field of the Right Eye With and Without Insulating Caps

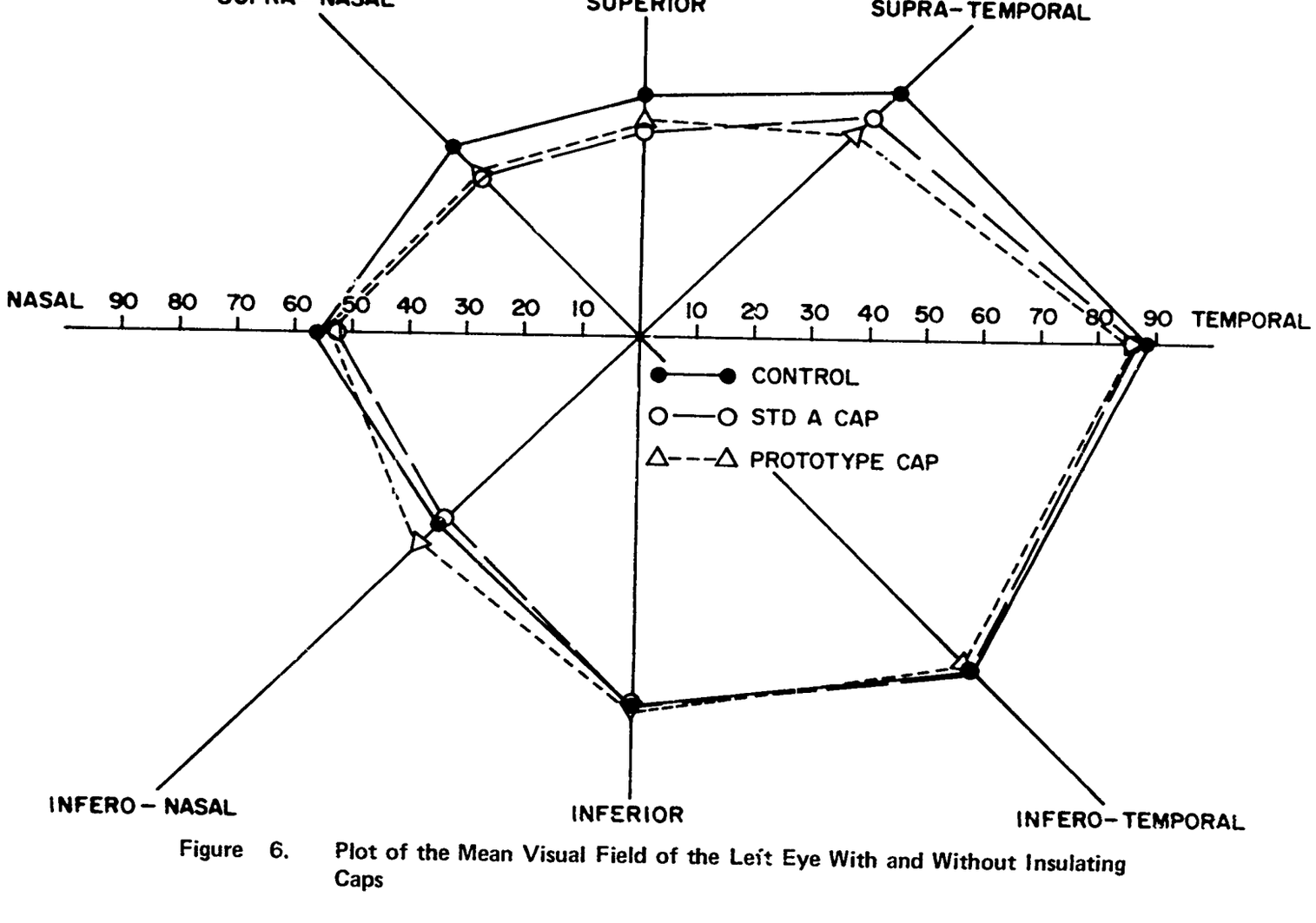

Figure 6. Plot of the Mean Visual Field of the Left Eye With and Without Insulating Caps

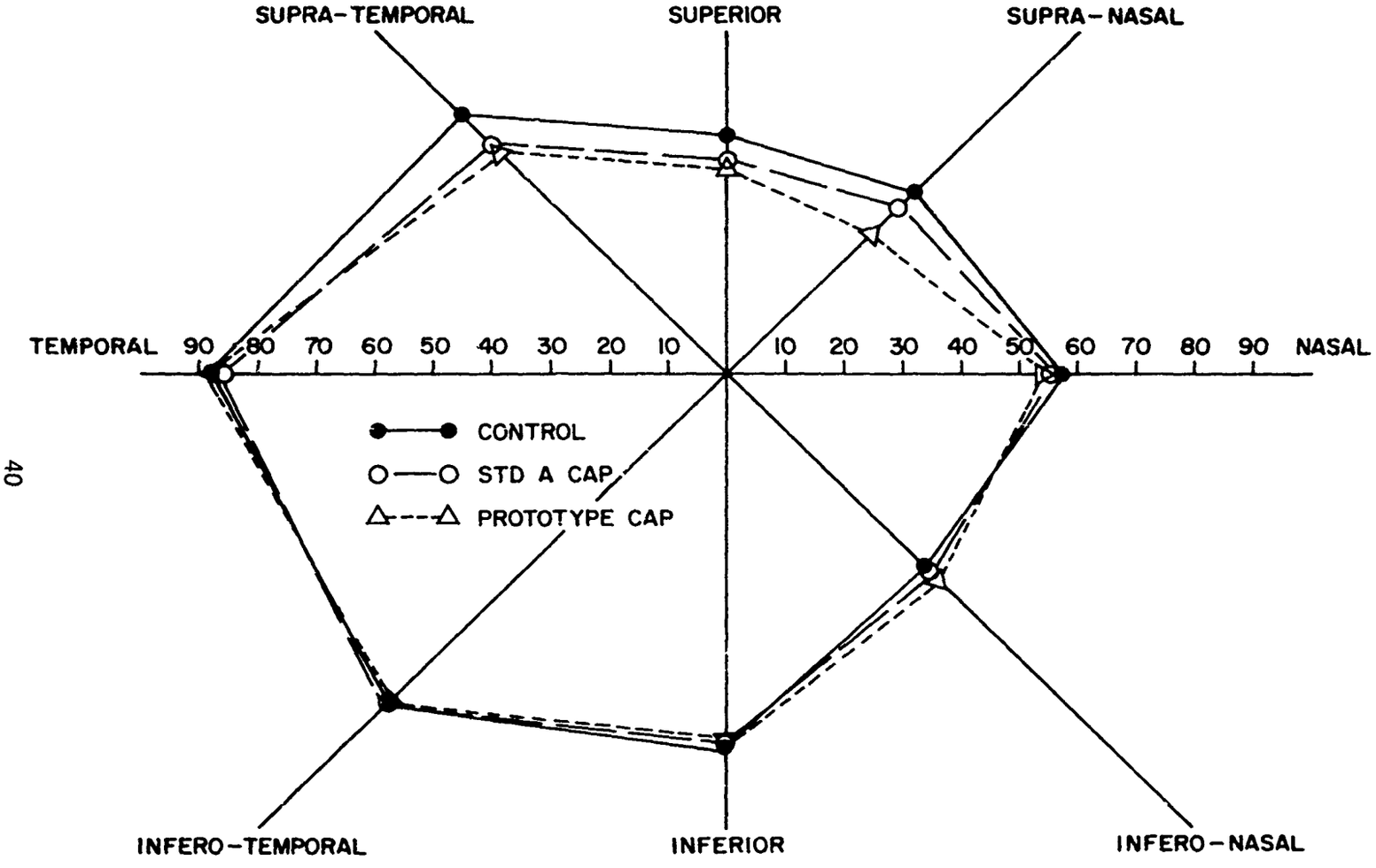

Figure 7. Plot of the Mean Visual Field of Both Eyes With and Without Insulating Caps

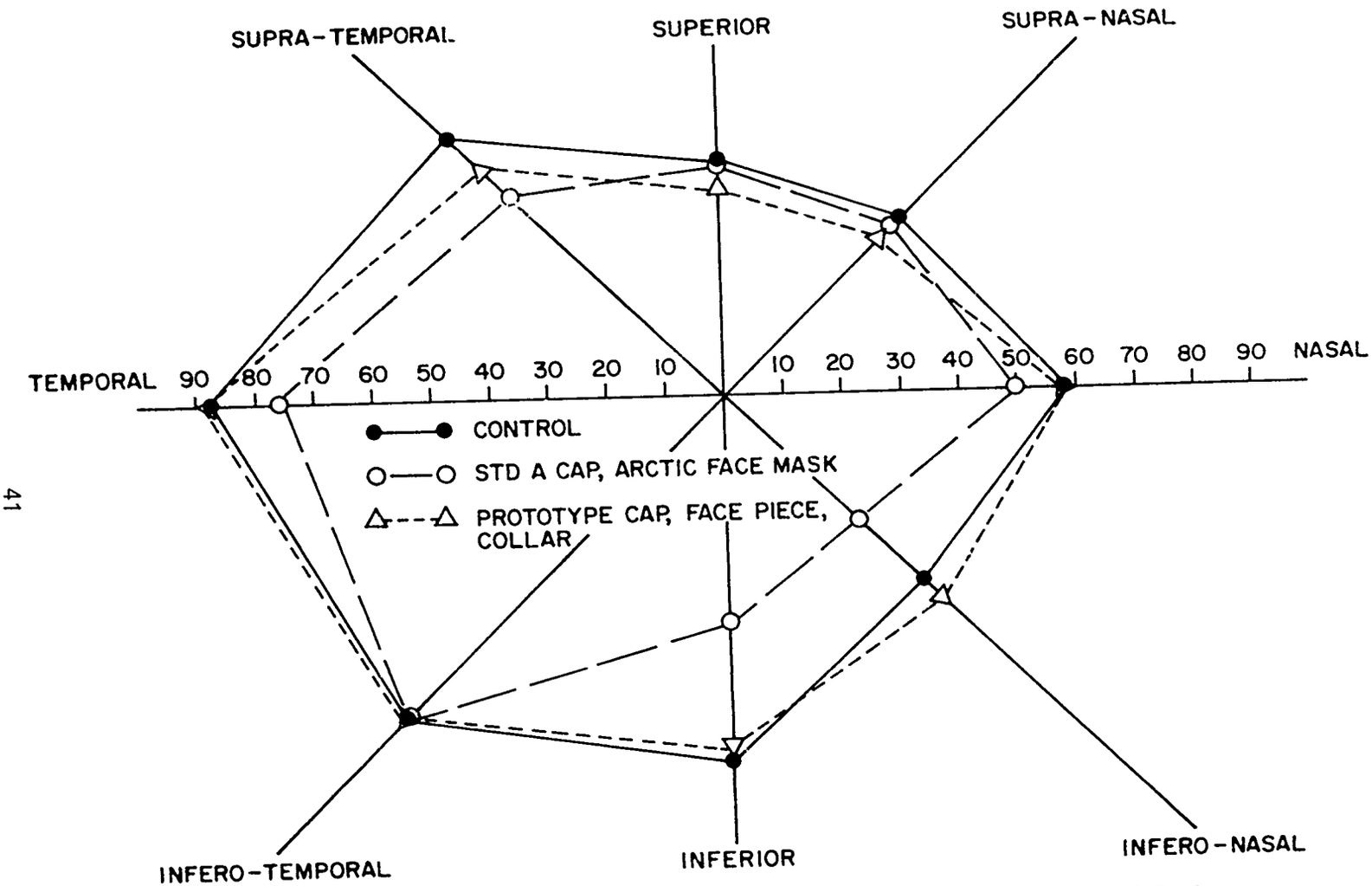

Figure 8. Plot of the Mean Visual Field of the Right Eye as a Function of Cold Weather Headgear Systems

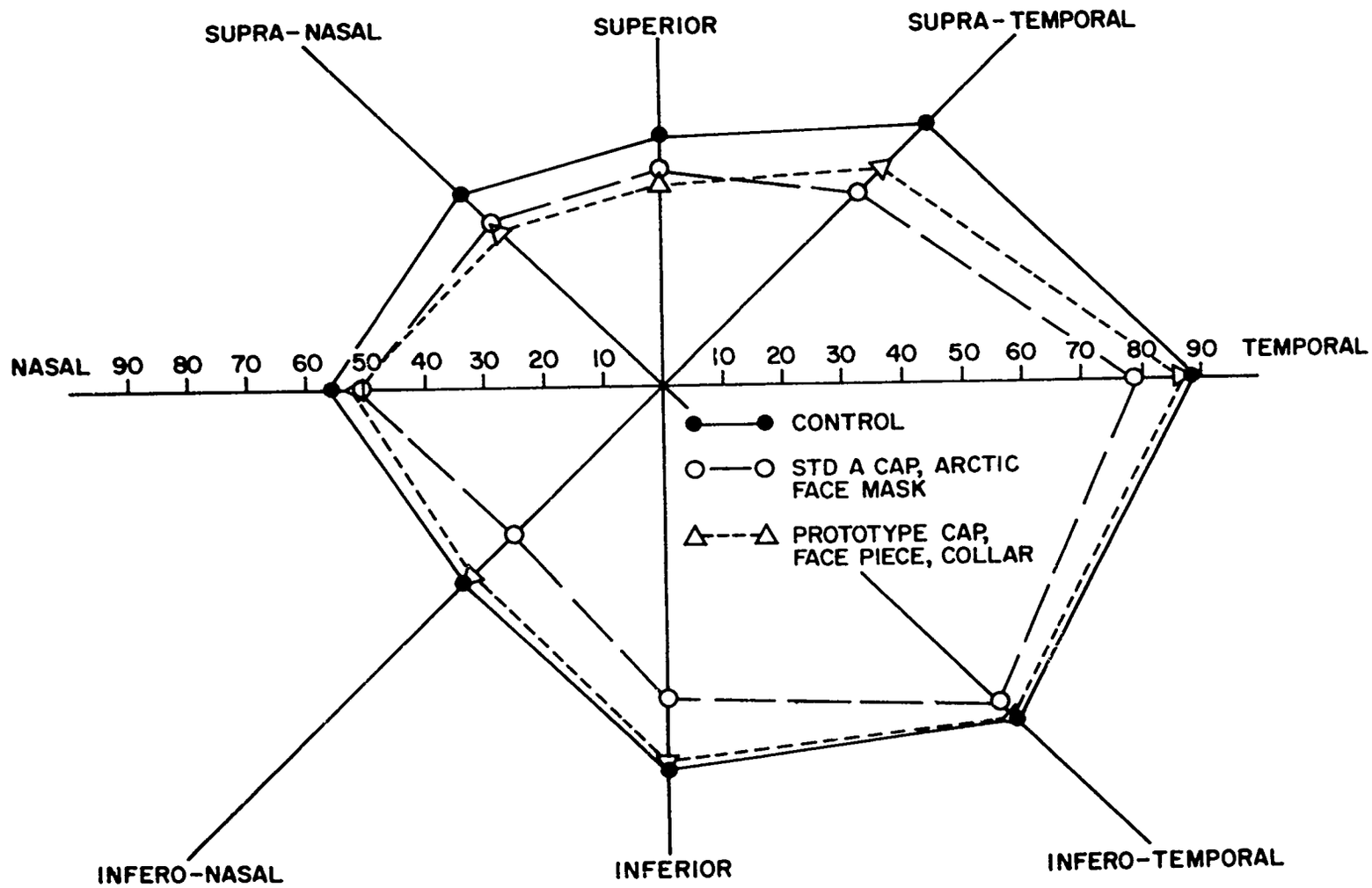

Figure 9. Plot of the Mean Visual Field of the Left Eye as a Function of Cold Weather Headgear Systems

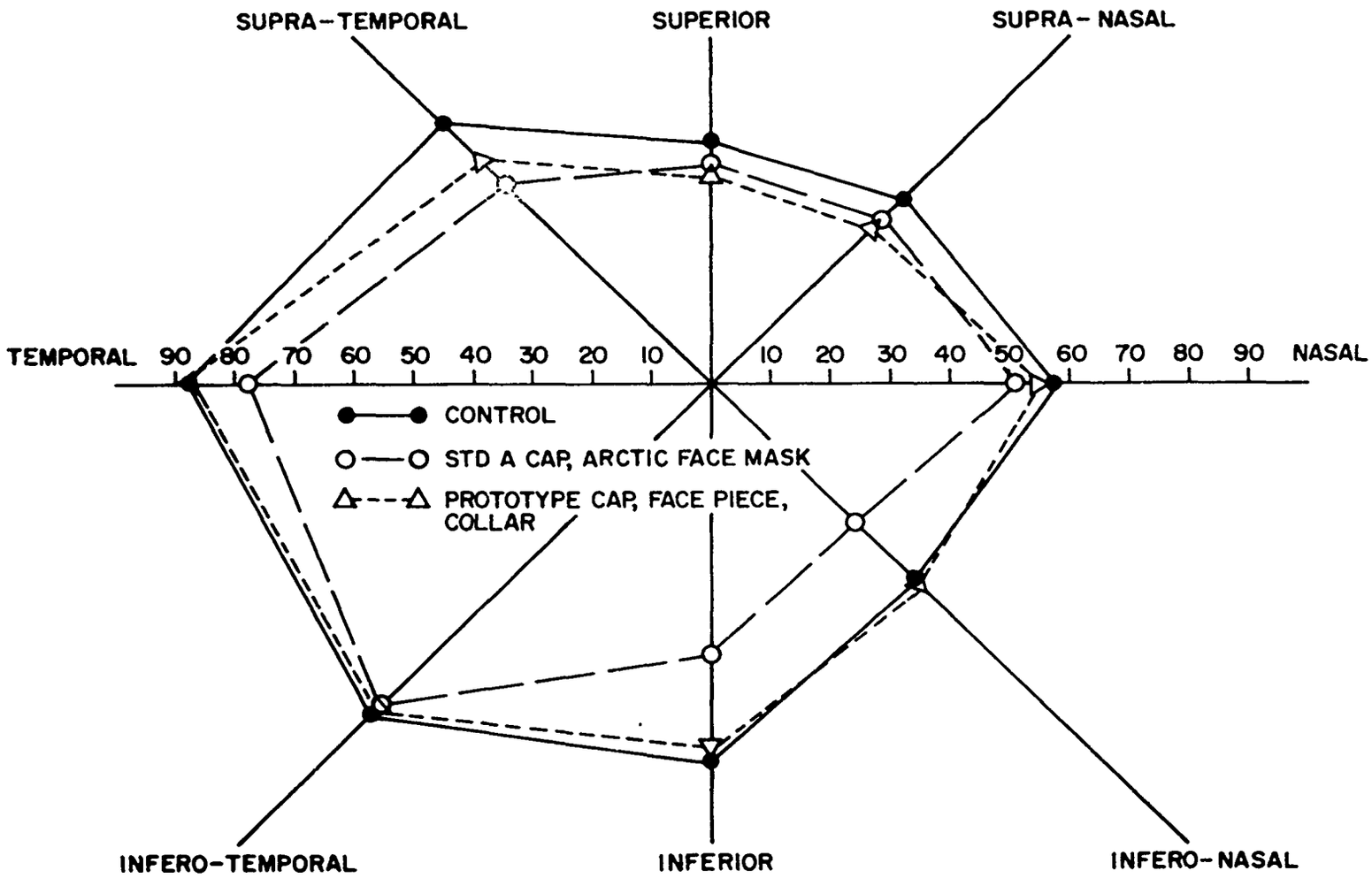

Figure 10. Plot of the Mean Visual Field of Both Eyes as a Function of Cold Weather Headgear Systems

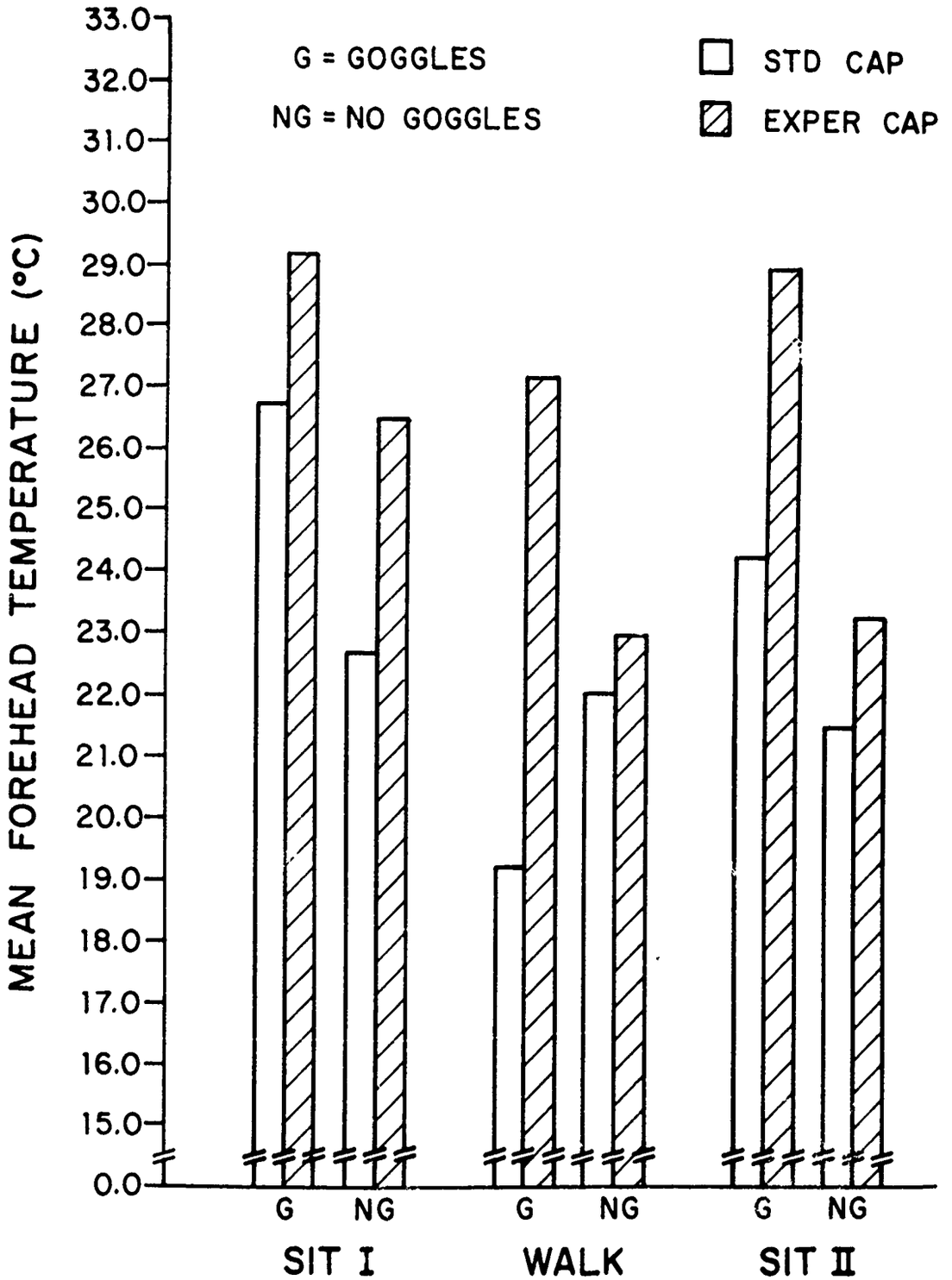

Figure 11. Mean Forehead Temperature at −6.7°C as a Function of Phase, Headgear, and Eyecover

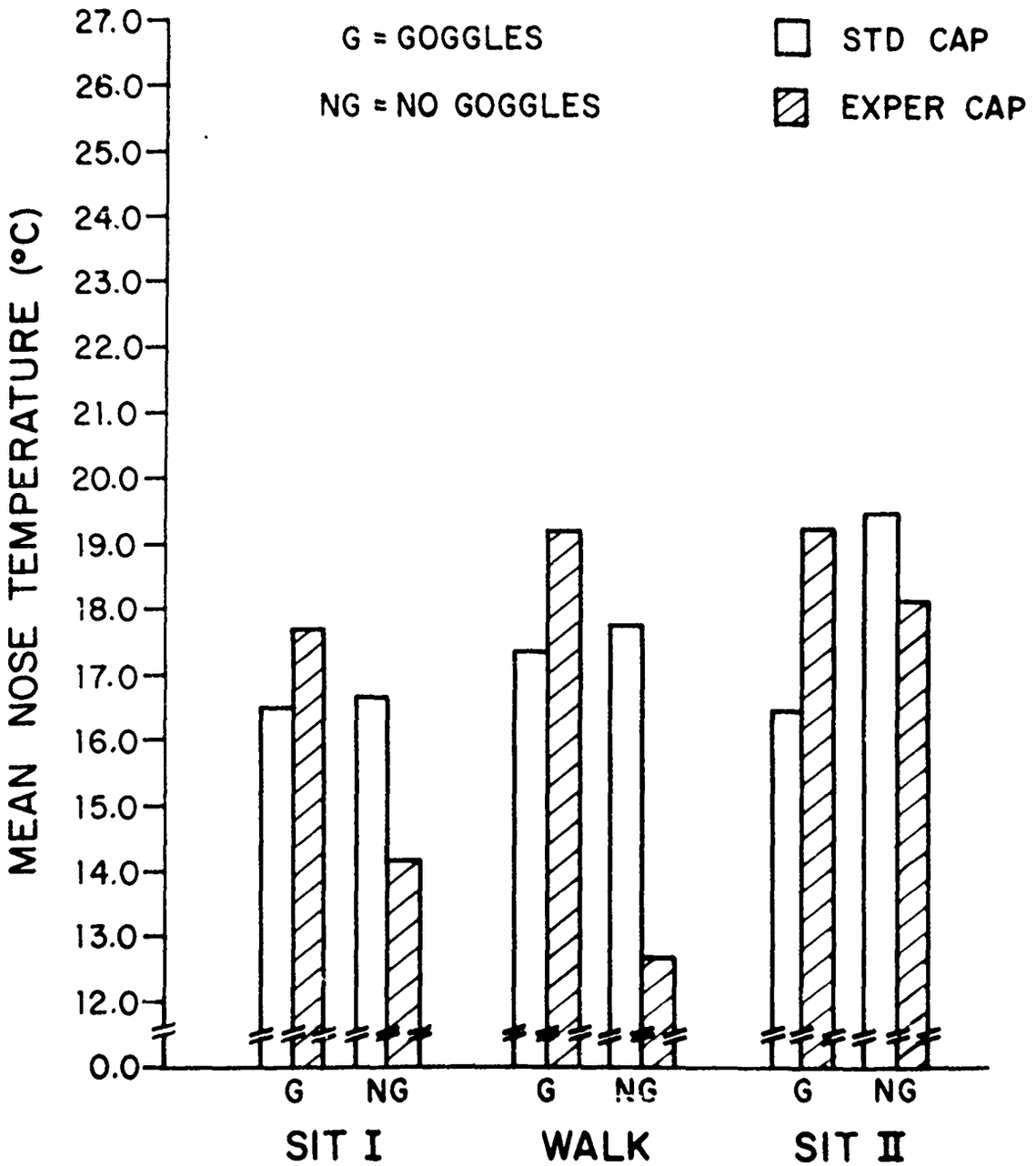

Figure 12. Mean Tip of Nose Temperatures at −6.7°C as a Function of Phase, Headgear, and Eyecover

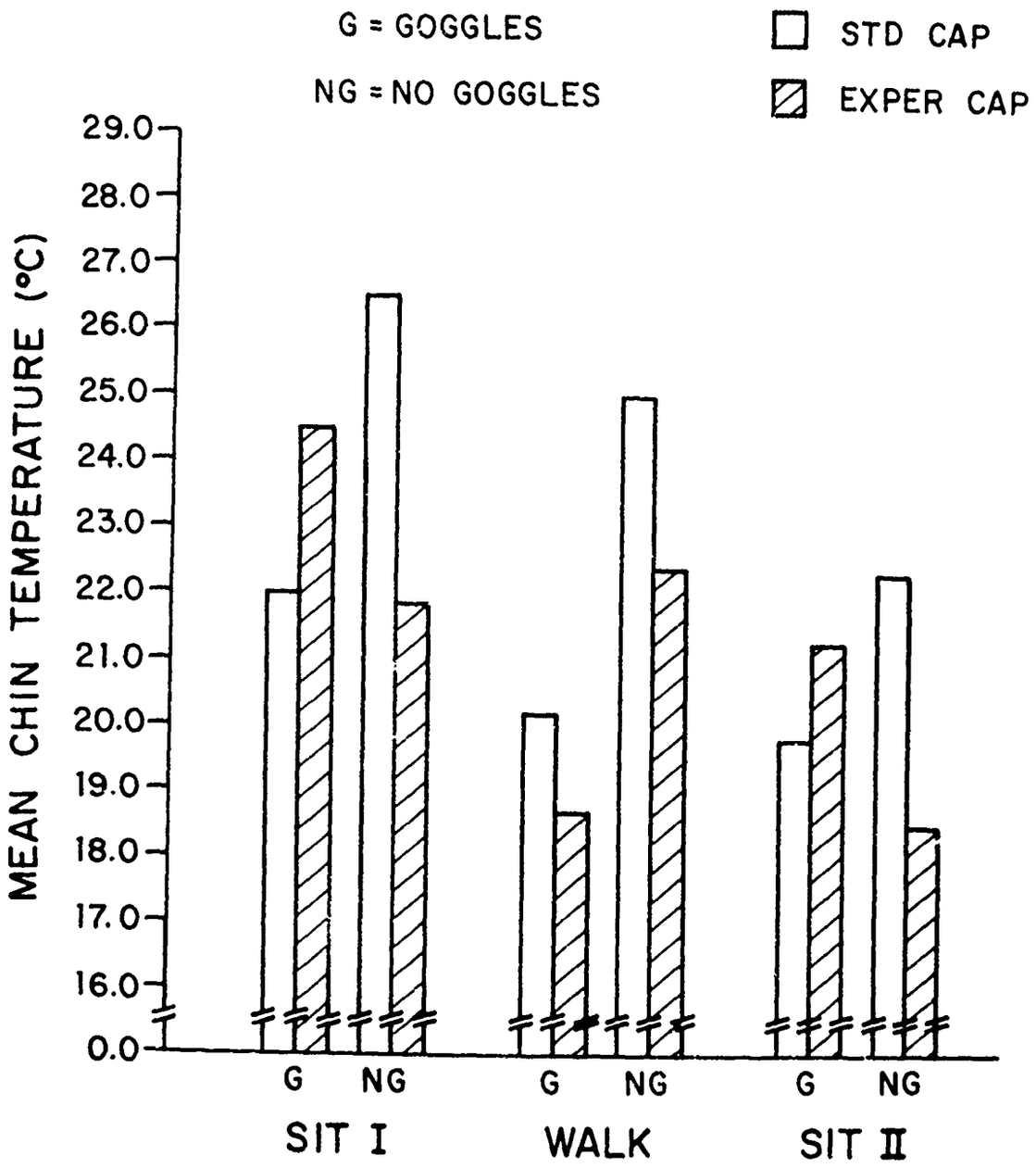

Figure 13. Mean Chin Temperatures at −6.7°C as a Function of Phase, Headgear, and Eyecover

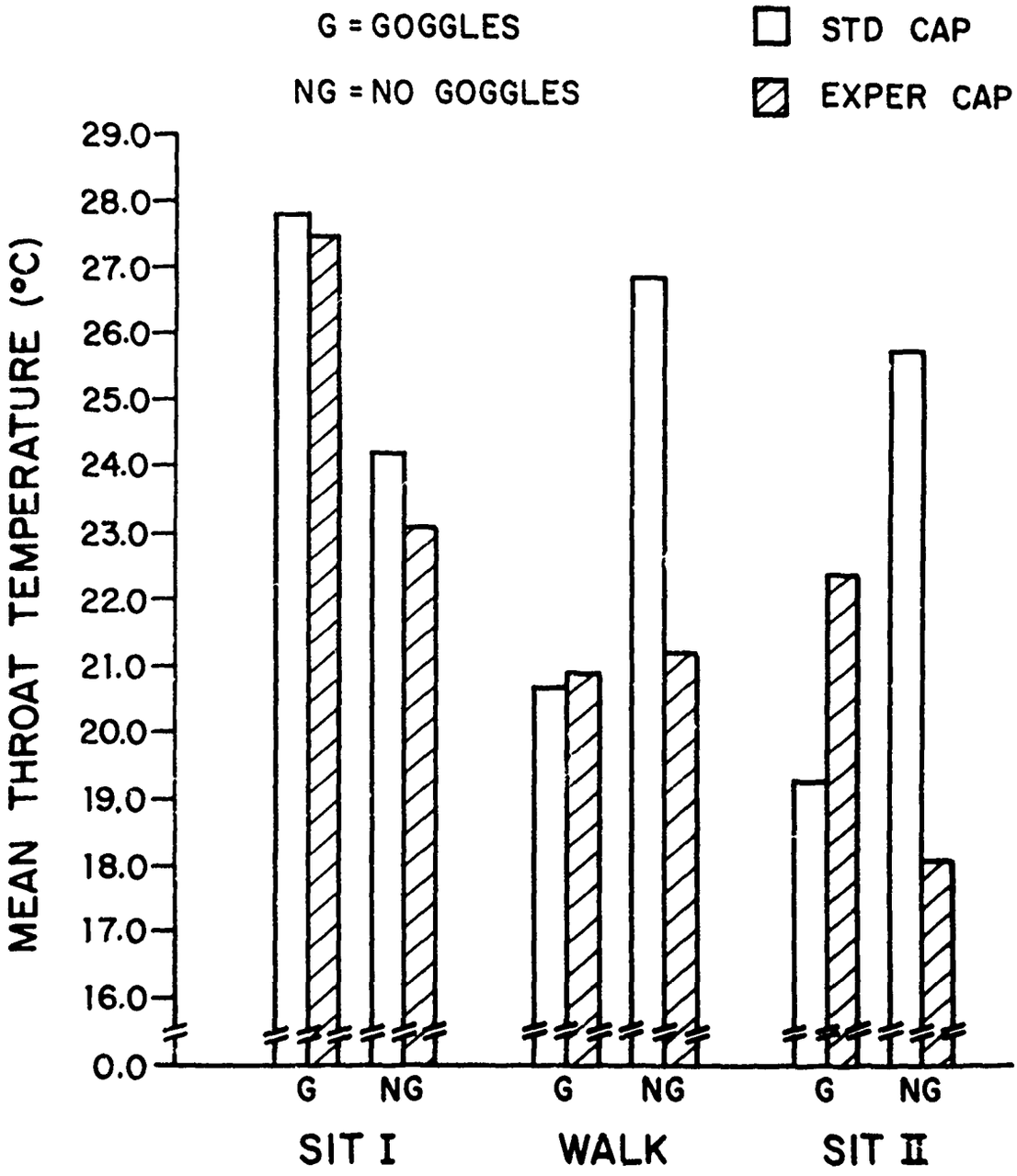

Figure 14. Mean Throat Temperatures at −6.7°C as a Function of Phase, Headgear, and Eyecover

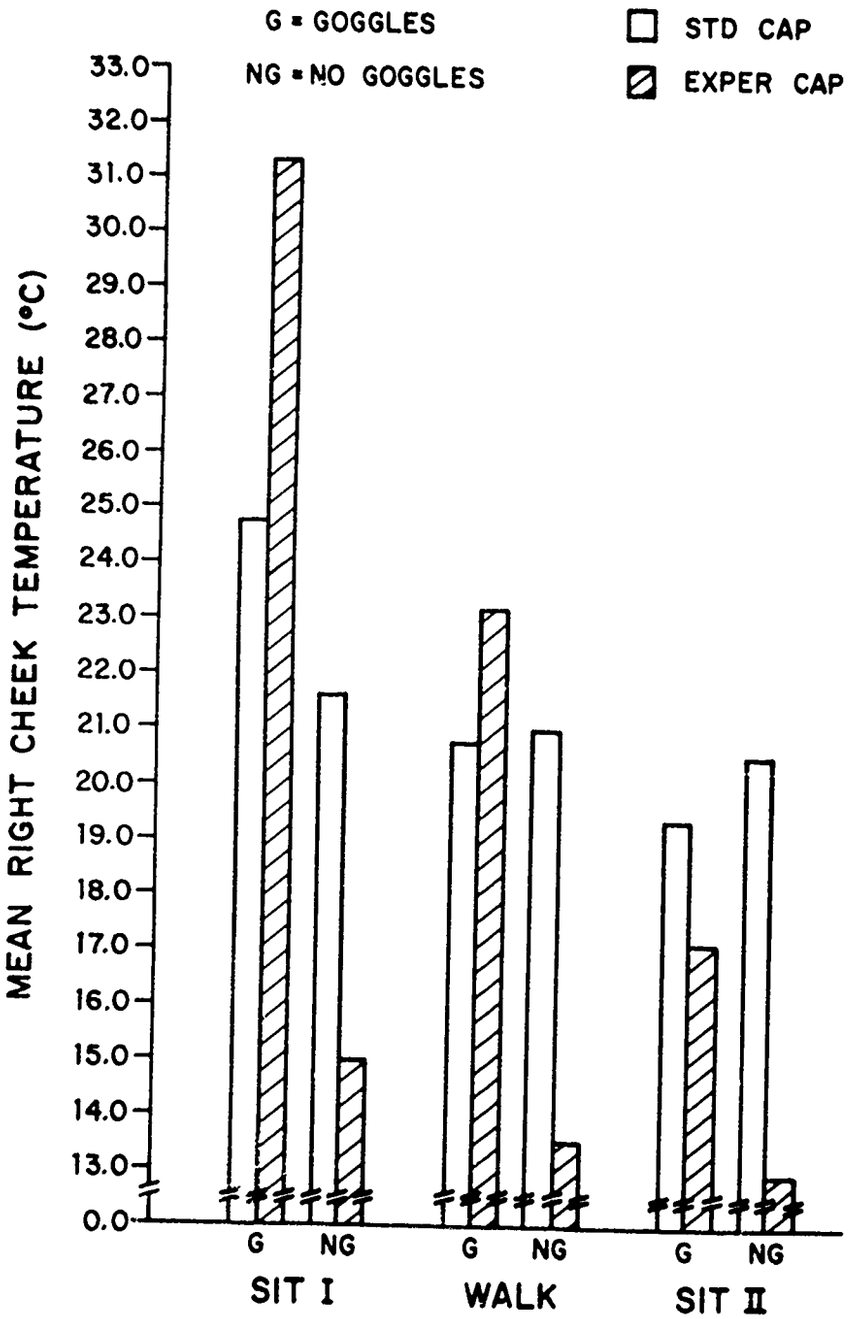

Figure 15. Mean Right Cheek Temperatures at −6.7°C as a Function of Phase, Headgear, and Eyecover

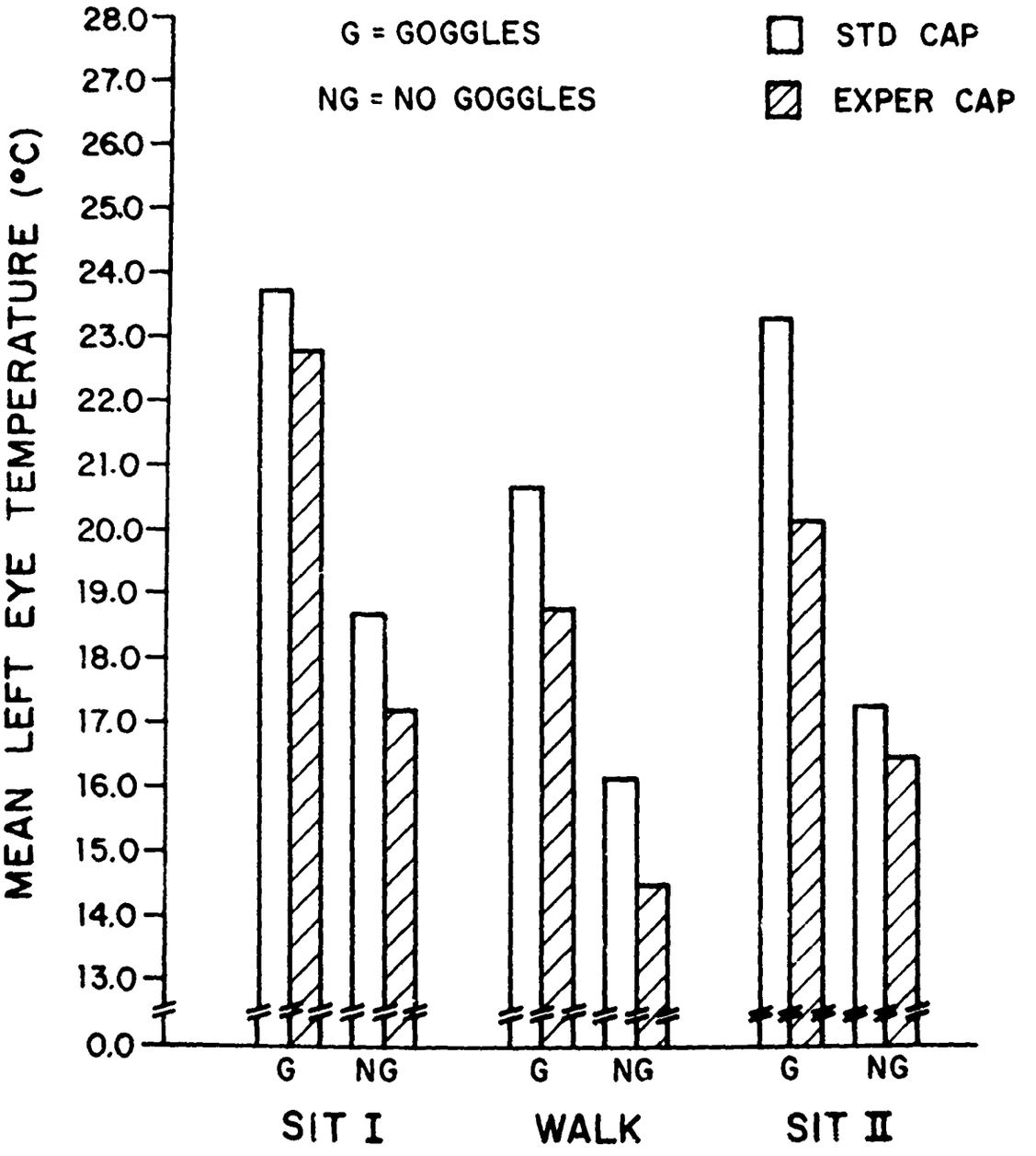

Figure 16. Mean Left Eye Temperatures at −6.7°C as a Function of Phase, Headgear, and Eyecover

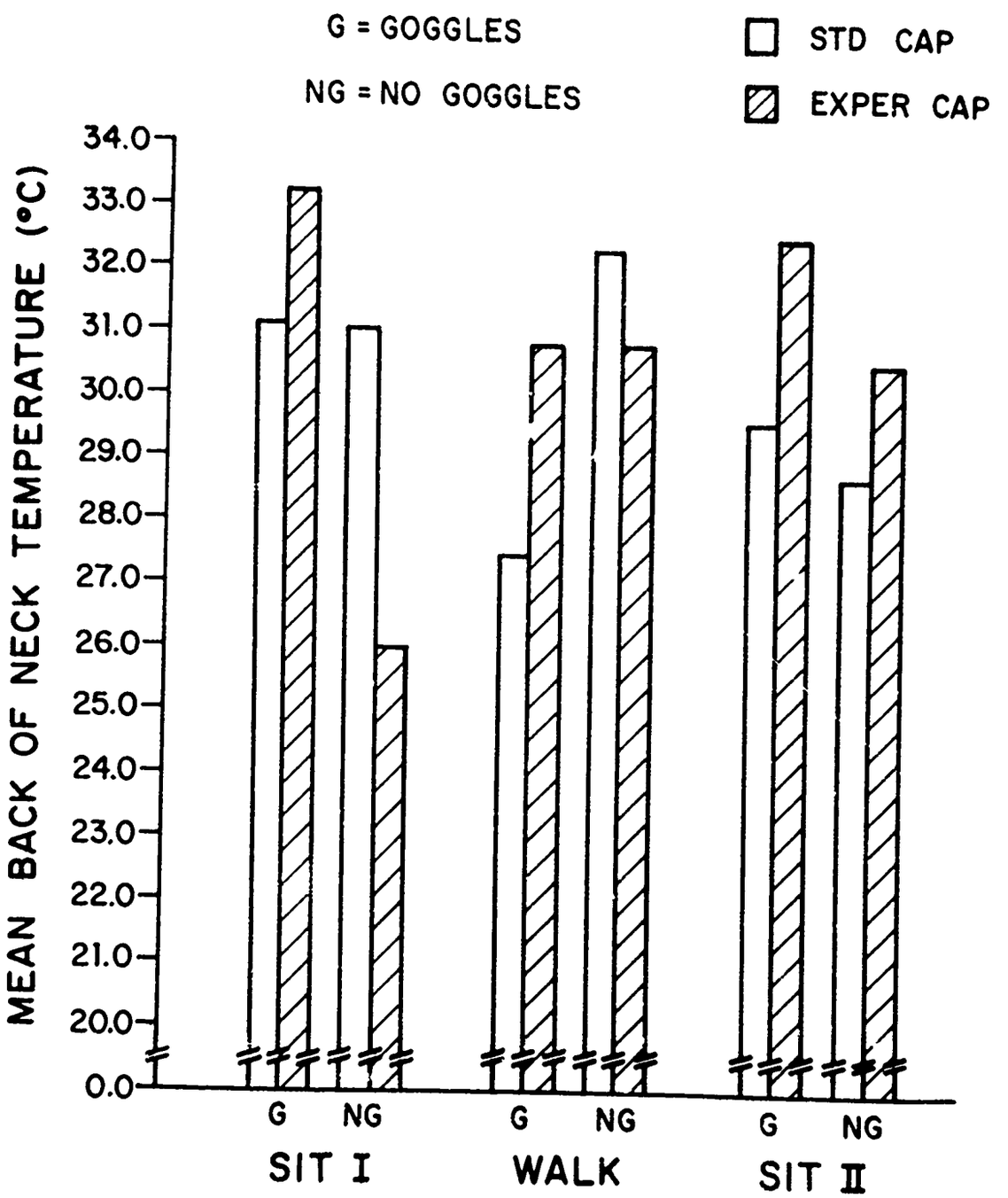

Figure 17. Mean Back of Neck Temperatures at −6.7°C as a Function of Phase, Headgear, and Eyecover

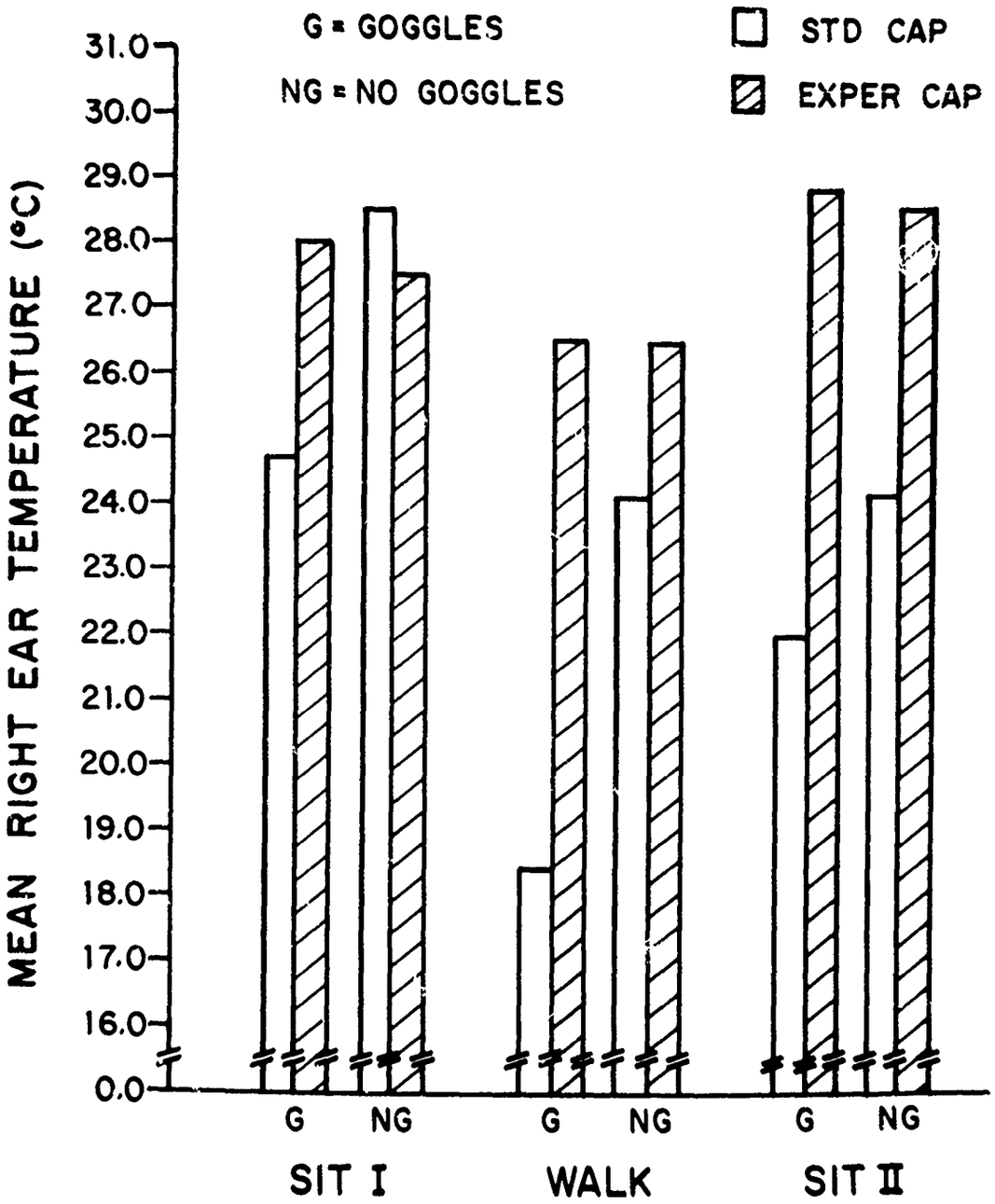

Figure 18. Mean Right Ear Temperatures at −6.7°C as a Function of Phase, Headgear, and Eyecover

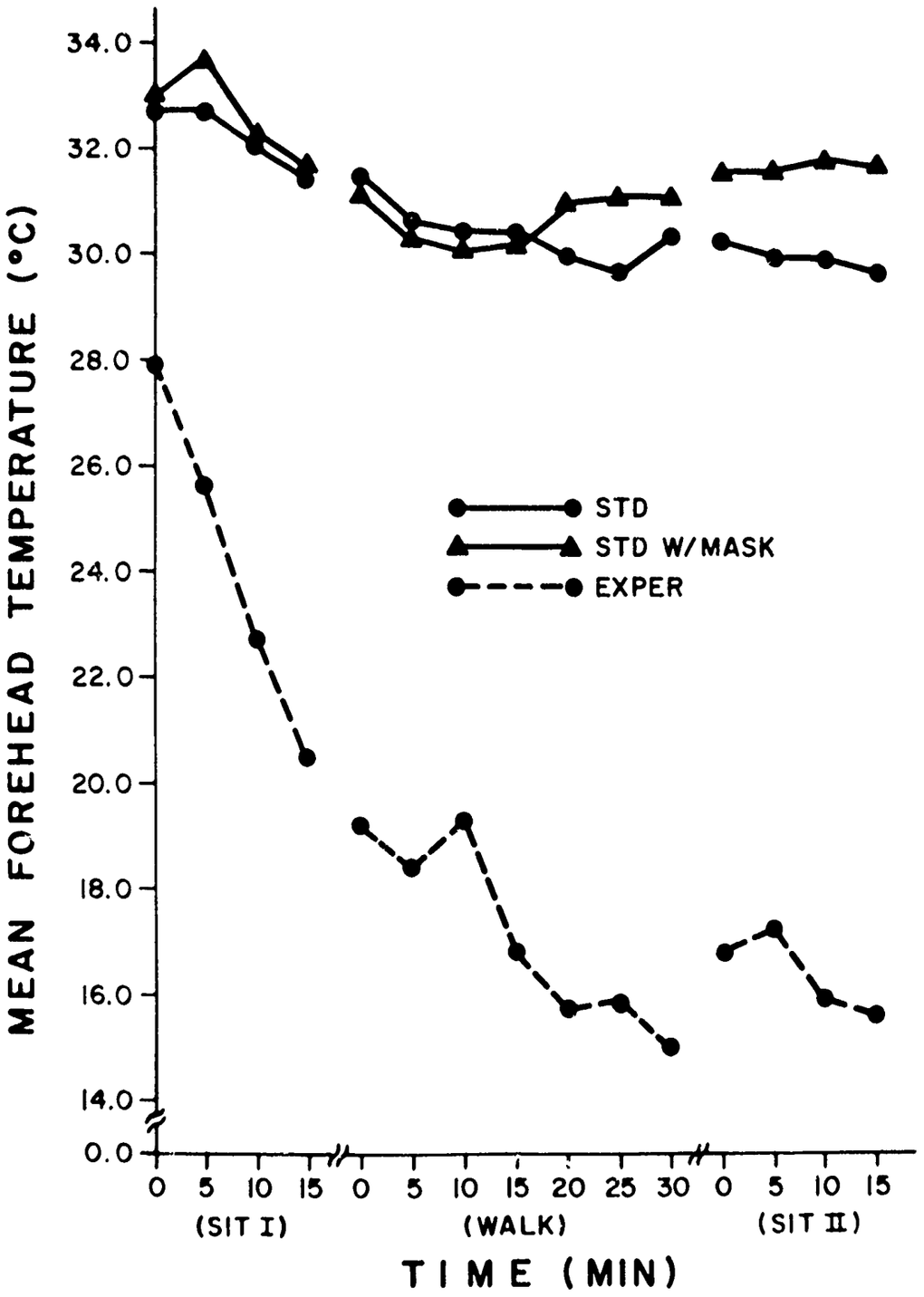

Figure 19. Mean Forehead Temperatures of Subjects With Eyecover During Exposure to −45.6°C

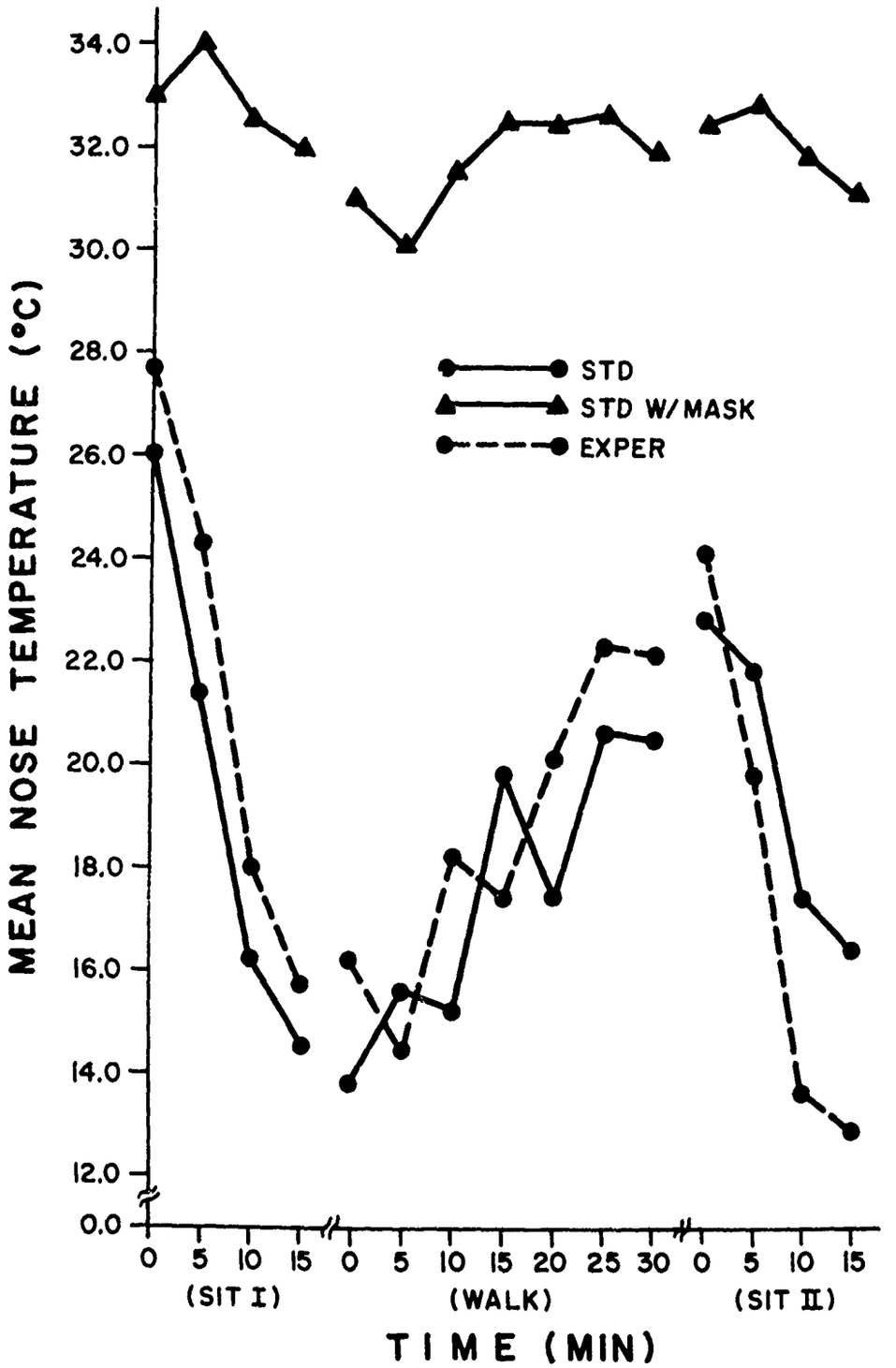

Figure 20. Mean Tip of Nose Temperatures of Subjects With Eyecover During Exposure to −45.6°C

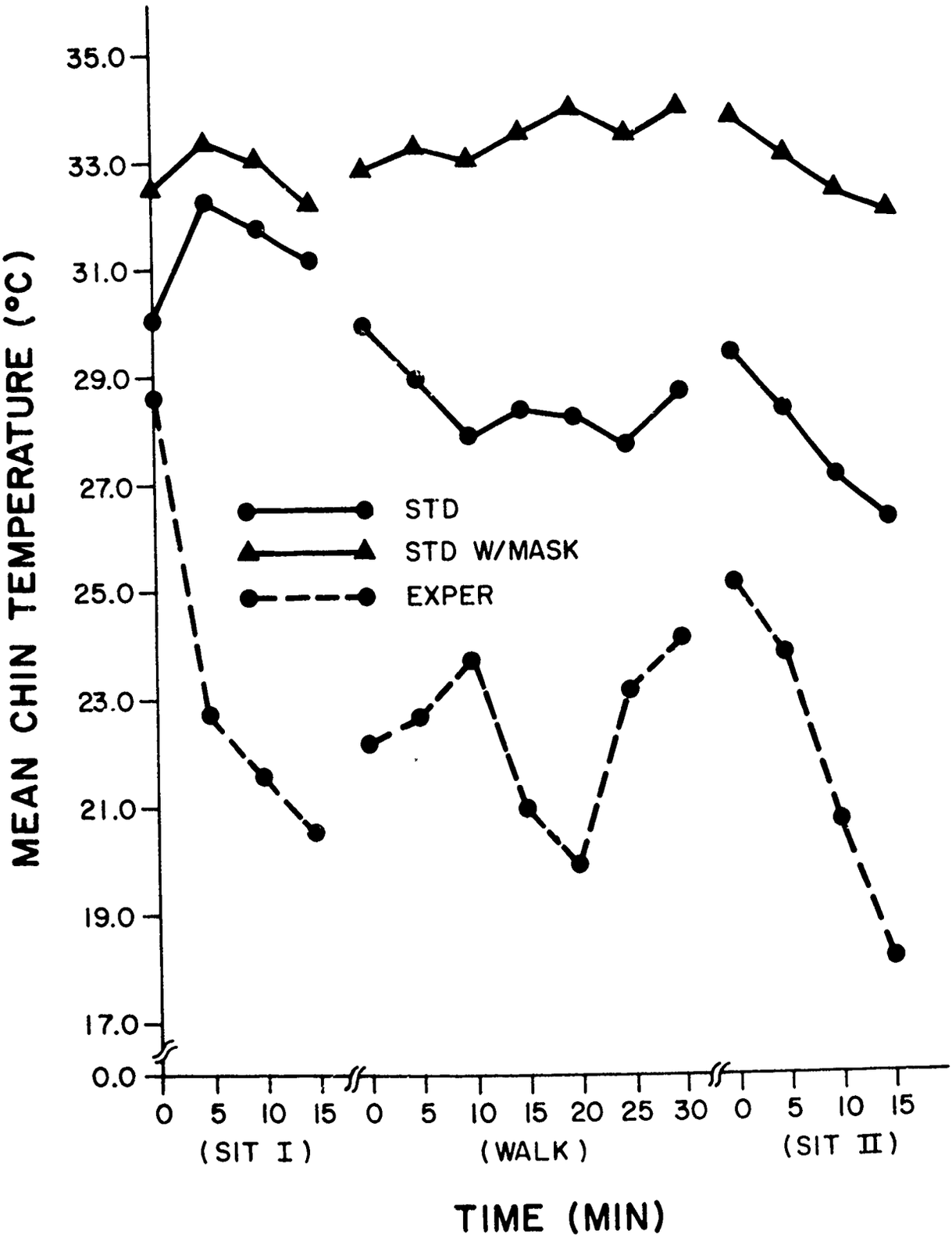

Figure 21. Mean Chin Temperatures of Subjects With Eyecover During Exposure to −45.6°C

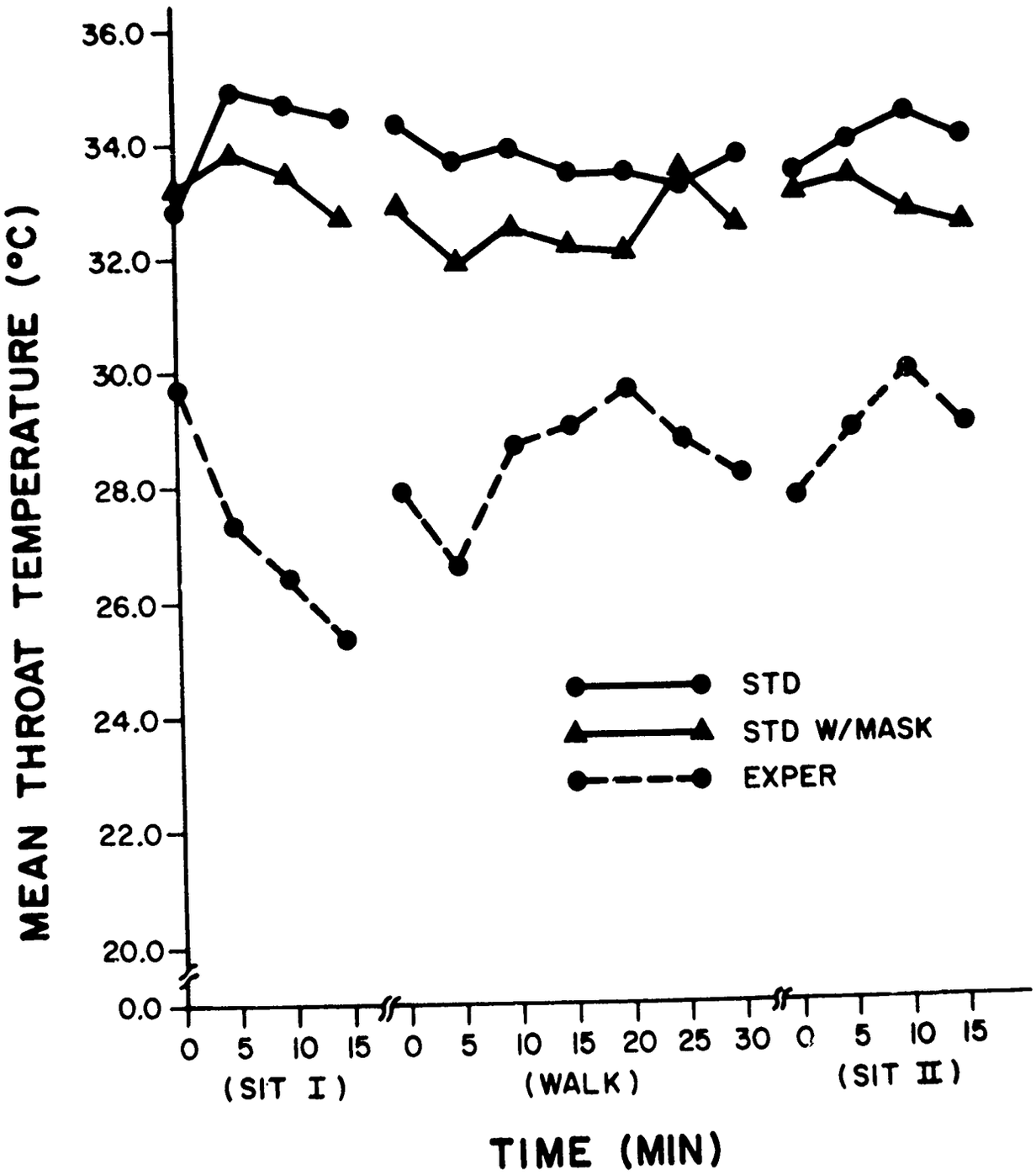

Figure 22. Mean Throat Temperatures of Subjects With Eyecover During Exposure to −45.6°C

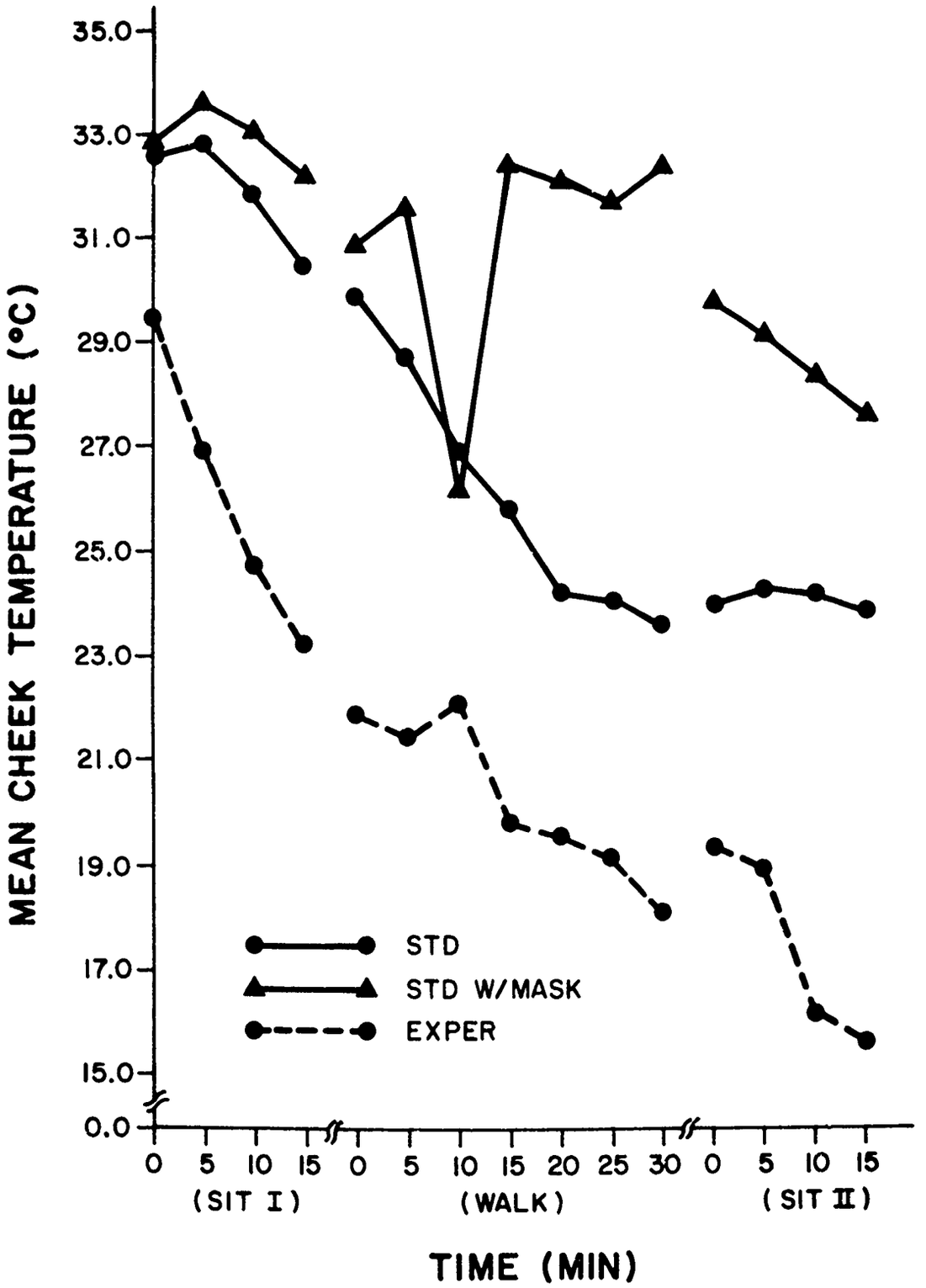

Figure 23. Mean Right Check Temperatures of Subjects With Eyecover During Exposure to −45.6°C

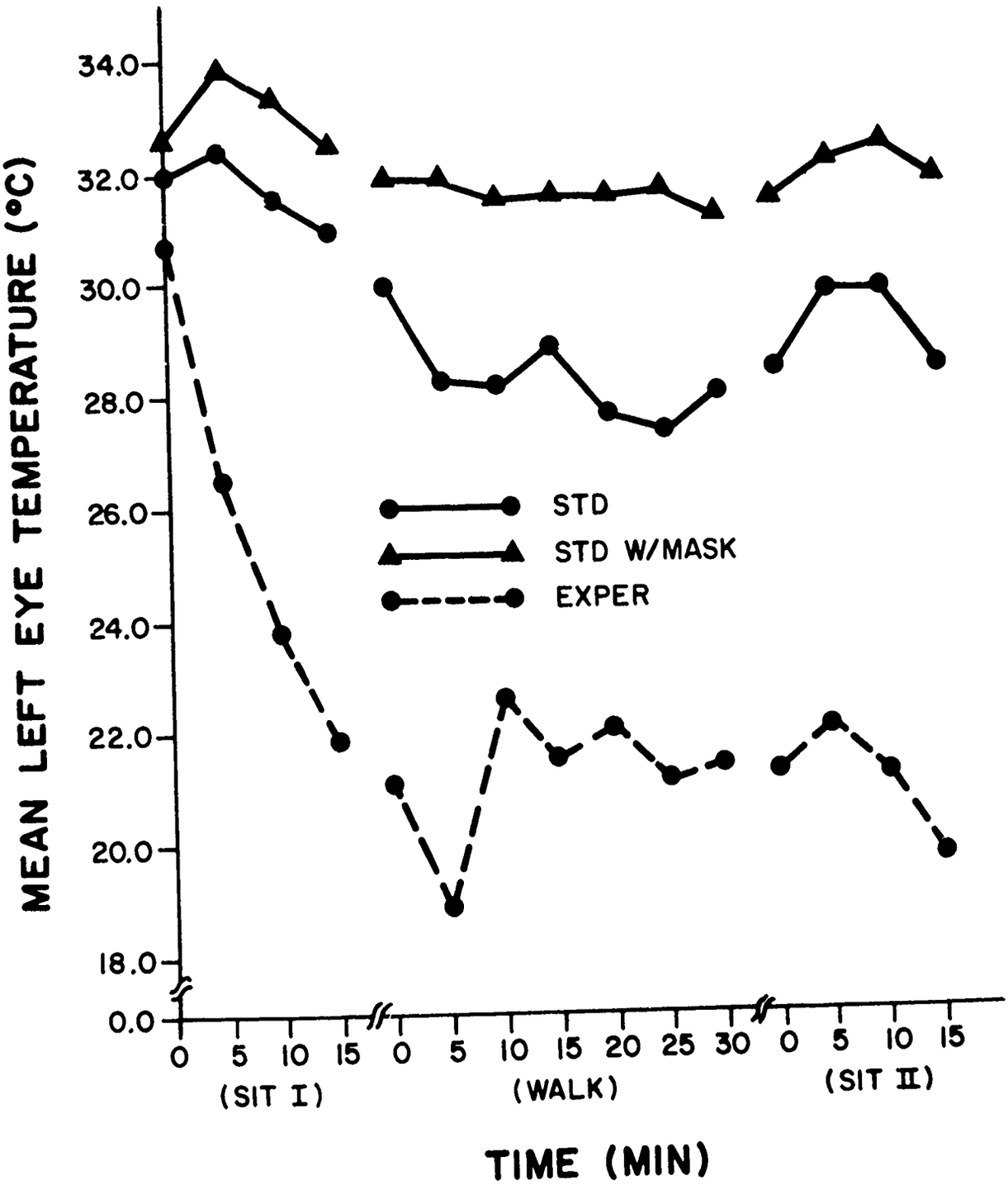

Figure 24. Mean Temperatures Below the Left Eye of Subjects With Eyecover During Exposure to −45.6°C

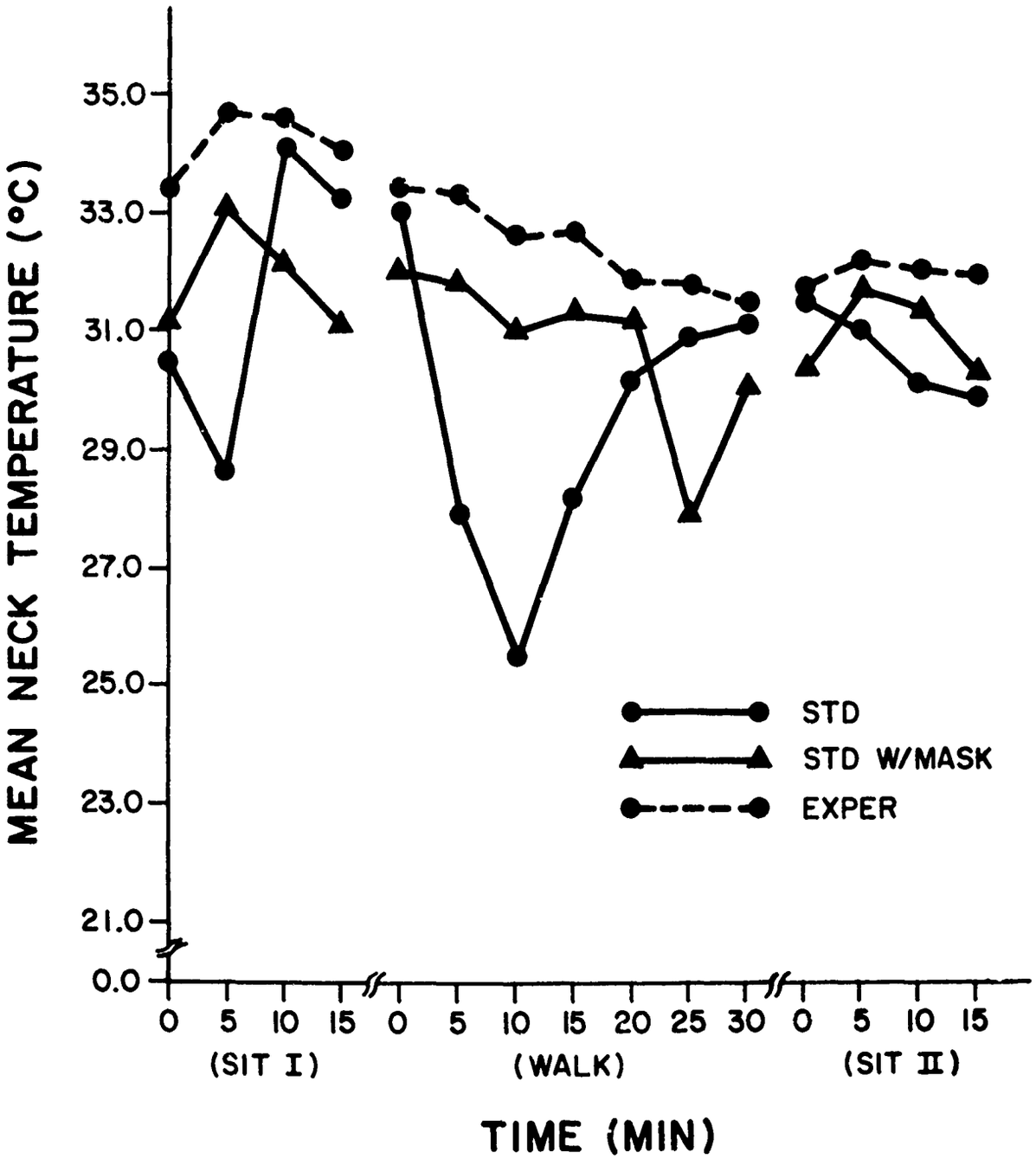

Figure 25. Mean Back of Neck Temperatures of Subjects With Eyecover During Exposure to −45.6°C

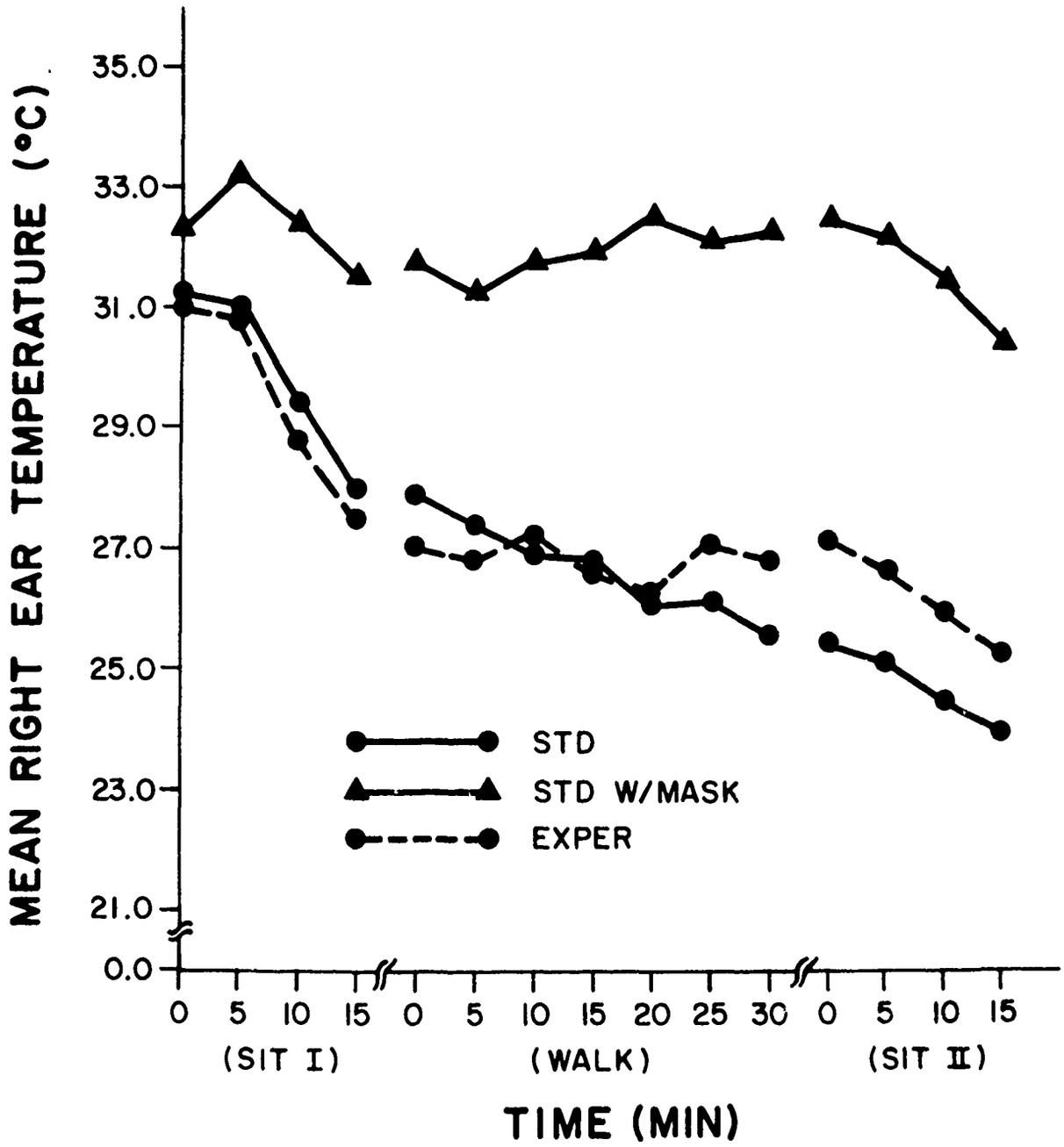

Figure 26. Mean Right Ear Temperatures of Subjects With Eyecover During Exposure to –45.6°C

TABLE 1

Results of Analysis of Variance of Pre-Chamber Test Data

Source of Variance	Tests								
		Rifle Aiming Cold-Wet			Rifle Aiming Cold-Dry			Donning W/Mittens	
	df	MS	F	p	MS	F	p	MS	F	p
Subjects (Ss)	7	0.43			0.34			407.02		
Headgear (H)	1	0.12	<1		1.14	2.19	NS	1,904.23	5.95	.05
Ss x H	7	0.26			0.52			319.84		

		Donning W/Wool Inserts			Ventral-Dorsal Head Movements Cold-Wet			Ventral-Dorsal Head Movements Cold-Dry		
	df	MS	F	p	MS	F	p	MS	F	p
Subjects (Ss)	7	164.18			474.71			558.99		
Headgear (H)	1	2,050.05	21.10	.005	1,097.27	5.89	.05	169.00	2.41	NS
Ss x H	7	97.15			186.22			70.06		

		Rotation Head Movements Cold-Wet			Rotation Head Movements Cold-Dry		
	df	MS	F	p	MS	F	p
Subjects (Ss)	7	589.96			593.66		
Headgear (H)	1	1,530.77	23.34	.005	3,199.32	11.78	.025
Ss x H	7	65.59			271.57		

TABLE 2

Mean Pre-Chamber Test Data

Tests	Standard Cap	Expermental Cap	p
Rifle-Aiming Cold-wet	3.4s	3.5s	NS
Rifle-Aiming Cold-dry	4.0s	3.5s	NS
Donning W/Mittens	37.4s	59.3s	.05
Donning W/Wool Inserts	18.9s	41.5s	.005
Ventral-Dorsal Head Movement Cold-wet	144°	128°	.05
Ventral-Dorsal Head Movement Cold-dry	135°	128°	NS
Rotation Head Movement Cold-wet	145°	125°	.005
Rotation Head Movement Cold-dry	91°	119°	.025

TABLE 3

Conditions of Subjects Removed from Chamber Test

Subject	Chamber Temp. (°C)	Eyecover	Headgear	Exposure Duration (min)	Thermo. Point
1	−17.8	Goggles	Std.	17	Neck
2	−17.8	Goggles	Exper.	17	Nose
3	−17.8	None	Std.	15	Chin
4	−17.8	None	Exper.	17	Cheek
3	− 6.7	None	Exper.	20	Cheek
7	− 6.7	None	Std.	17	Nose
3	−45.6	None	Exper.	20	Nose
4	−45.6	None	Std.	19	Nose
6	−45.6	Goggles	Std.	18	Nose
7	−45.6	None	Std.	11	Nose

TABLE 4

Significant Effects from Analyses of Sit I Phase

Measure	Source of Variance	df	Mean Square	F	*p*
Right Cheek	Headgear	2/8	556.09/21.07	26.39	0.001
	Headgear x Time	6/24	11.10/4.62	2.40	0.10
Left Eye	Eyecover	1/4	329.39/40.48	8.14	0.05
	Headgear	2/8	367.75/16.41	22.40	0.001
	Time	3/12	33.83/0.89	38.04	0.001
	Eyecover x Headgear	2/8	59.13/16.41	3.60	0.10
	Headgear x Time	6/24	17.45/1.42	12.26	0.001
Right Ear	Headgear	2/8	117.57/16.63	7.07	0.025
	Time	3/12	17.02/1.19	14.35	0.001
	Headgear x Time	6/24	3.55/1.07	3.31	0.025
Forehead	Headgear	2/8	312.89/38.45	8.14	0.025
	Time	3/12	56.11/1.18	47.54	0.001
	Headgear x Time	6/24	11.00/2.61	4.22	0.005
Nose	Eyecover	1/4	253.88/45.01	5.64	0.10
	Headgear	2/8	1184.08/113.23	10.46	0.01
	Time	3/12	127.84/10.86	11.78	0.001
	Headgear x Time	6/24	23.92/3.80	6.29	0.001
	Eyecover x Headgear x Time	6/24	7.84/3.80	2.06	0.10
Chin	Headgear	2/8	703.64/55.58	12.66	0.005
	Headgear x Time	6/24	42.56/10.77	3.95	0.01

TABLE 5

Mean Temperatures (°C) for Each Headgear Condition

Measure	Analysis: Sit I				Analysis: Sit I, II — Goggles				Analysis: Walk—Goggles			
Forehead	S	S/M	E	*p*	S/M	S	E	*p*	S/M	S	E	*p*
	30.3	28.6	23.4	.025	32.1	31.1	20.3	.005	30.6	30.4	17.2	.005
Nose	S/M	E	S		S/M	E	S		S/M	E	S	
	30.5	20.9	16.8	.01	32.4	19.6	19.5	.025	31.7	18.7	17.5	.01
Chin	S/M	S	E		S/M	S	E		S/M	S	E	
	31.7	31.0	22.0	.005	32.8	29.5	22.6	.05	33.4	28.5	22.4	NS
Throat	S	S/M	E		S	S/M	E		S	S/M	E	
	32.6	31.9	29.2	NS	34.1	33.1	28.1	NS	33.6	32.4	28.4	.10
Right Cheek	S/M	S	E		S/M	S	E		S/M	S	E	
	32.4	30.6	23.3	.001	30.8	28.0	21.8	NS	31.0	26.1	20.3	NS
Left Eye	S/M	S	E		S/M	S	E		S/M	S	E	
	32.0	27.7	24.2	.001	32.5	30.4	23.4	.001	31.5	28.3	21.2	.005
Neck	E	S/M	S		E	S/M	S		E	S/M	S	
	33.5	31.6	30.2	NS	33.1	31.4	31.2	NS	32.4	30.8	29.6	NS
Right Ear	S/M	S	E		S/M	E	S		S/M	E	S	
	32.9	30.8	28.5	.025	32.0	27.9	27.3	NS	31.9	26.9	26.7	NS

S = Std, S/M = Std W/Mask, E = Exper

Mean scores not connected by same line are significantly different ($p < .05$).

TABLE 6

Significant Effects from Analyses of Sit I and Sit II Phases

Measure	Source of Variance	df	Mean Square	F	*p*
Forehead	Phase	1/2	246.42/6.09	40.48	0.025
	Headgear	2/4	1023.10/31.38	32.61	0.005
	Time	3/6	15.71/0.44	36.11	0.001
	Phase x Headgear	2/4	78.93/0.57	139.24	0.001
	Phase x Time	3/6	7.43/0.91	8.14	0.025
	Headgear x Time	6/12	4.89/1.18	4.12	0.025
	Phase x Headgear x Time	6/12	2.22/0.63	3.50	0.05
Nose	Headgear	2/4	1328.28/101.23	13.12	0.025
	Time	3/6	209.04/2.70	77.41	0.001
	Headgear x Time	6/12	37.48/0.98	38.26	0.001
Chin	Headgear	2/4	647.59/90.24	7.18	0.05
	Time	3/6	34.64/6.77	5.12	0.05
	Headgear x Time	6/12	15.87/5.76	2.76	0.10
	Phase x Headgear x Time	6/12	5.15/2.05	2.51	0.10
Right Cheek	Phase	1/2	831.64/19.67	42.28	0.025
Left Eye	Phase	1/2	136.95/5.92	23.14	0.05
	Headgear	2/4	546.28/8.19	66.69	0.001
	Time	3/6	14.57/0.51	28.38	0.001
	Phase x Time	3/6	8.84/1.03	8.60	0.025
	Headgear x Time	6/12	9.81/1.26	7.79	0.005
	Phase x Headgear x Time	6/12	4.57/0.91	5.01	0.01
Right Ear	Time	3/6	19.14/0.45	42.37	0.001
	Phase x Headgear	2/4	30.09/6.23	4.83	0.10
	Phase x Time	3/6	1.25/0.12	10.45	0.01

TABLE 7

Significant Effects from Analyses of Walk Phase

Measure	Source of Variance	df	Mean Square	F	*p*
Forehead	Headgear	2/4	1234.53/26.32	46.91	0.005
	Headgear x Time	12/24	3.44/1.03	3.34	0.01
Nose	Headgear	2/4	1294.90/63.61	20.36	0.01
	Time	6/12	38.29/12.10	3.16	0.05
Throat	Headgear	2/4	156.06/24.04	6.49	0.10
Right Cheek	Headgear x Time	12/24	13.78/5.39	2.56	0.025
Left Eye	Headgear	2/4	582.00/11.48	50.69	0.005

APPENDIX A

Donning Instructions – Standard Hood with Fur Ruff

1. With the parka off, insert the upturned collar of the parka between the two layers of the hood.

2. Button the outer layer of the hood to the buttonholes on the collar of the parka.

3. Fasten the inner layer of the hood to the buttons on the inside of the parka below the neck.

4. Snap the stud on the inside right flap of the hood to the snap socket on the inside right lapel of the parka.

5. Don the parka.

6. With the hood on your head, bring the left neck flap over to your right. Secure the hood by pressing down on the materia and buttoning the flap.

7. Adjust the drawcords around the edge of the hood for a comfortable fit.

Donning Instructions – Experimental Headgear

1. Put the parka on and fasten it closed. Leave the collar up.

2. Separate the two flaps of material at the back of the cap. Fold the outer flap into an upward position.

3. Put on the cap with the inner flap of material inside the parka collar. Leave the outer flap of the cap in an upward position.

4. Fold the right hand tongue of the cap across your throat to the left hand side of your neck under your chin. Cross the left hand tongue to the right under your chin. Attach the tongues together by pressing down on the material.

5. Put on the collar by placing it around your neck. Fold the outer flap of the cap down over the collar.

6. Bring the right hand tongue of the collar across under your chin. Bring the left hand tongue under your chin. Attach the tongues together by pressing down on the material.

7. Center the face covering with its upper edge below the eyes and in contact with the bony ridge of the nose.

8. Mold the upper edge of the face cover against your face under your eyes. Press the end tabs of the face cover onto the sides of the cap.

9. Fold out the excess material in the face covering and fold the flaps over one another. Secure the flaps using the tape.

10. To take off the headgear, remove the face covering. Unfasten the flaps under your chin and lift off the cap and collar, keeping them fastened to each other.

APPENDIX B

Questionnaire: Pre-Chamber Testing

Name: Date:
Headgear:

1a. How clear were the instructions telling you how to put on and take off the headgear?

_____ Clear _____ Unclear

If they were not clear, why not?

1b. I found the fit of the headgear to be

a. _____ Very comfortable
b. _____ Comfortable
c. _____ Neither comfortable nor uncomfortable
d. _____ Uncomfortable
e. _____ Very uncomfortable

2. While you were wearing the Arctic mittens, did you have any difficulty putting on the headgear?

a. _____ Much difficulty
b. _____ Some difficulty
c. _____ No difficulty
d. _____ It was easy

3. While you were wearing the Arctic mittens, did you have any difficulty taking off the headgear?

a. _____ Much difficulty
b. _____ Some difficulty
c. _____ No difficulty
d. _____ It was easy

4. While you were wearing the wool insert mittens, did you have any difficulty putting on the headgear?

a. _____ Much difficulty
b. _____ Some difficulty
c. _____ No difficulty
d. _____ It was easy

5. While you were wearing the wool insert mittens, did you have any difficulty taking off the headgear?

a. ____ Much difficulty
b. ____ Some difficulty
c. ____ No difficulty
d. ____ It was easy

6. Did the insulating cap worn alone interfere in any way with your being able to sight with the rifle?

a. ____ Interfered a great deal
b. ____ Interfered a little
c. ____ Did not interfere

7. Did insulating cap and Arctic headgear interfere in any way with your being able to sight with the rifle?

a. ____ Interfered a great deal
b. ____ Interfered a little
c. ____ Did not interfere

Specifically, what were the problems involved?

8. Did the insulating cap interfere in any way with

a. Your being able to take water from the glass? ____ Yes ____ No

If so, describe:

b. Your being able to spit out the water? ____ Yes ____ No

If so, describe:

c. Did the insulating cap get wet while you were drinking the water?

____ Yes ____ No

9. Did the insulating cap interfere in any way with your being able to smoke?

a. _____ Interfered a great deal
b. _____ Interfered a little
c. _____ Did not interfere
d. _____ Did not smoke

Specifically, what were the problems involved?

10. Do you think you could eat if you had to while wearing the insulating cap?

____ Yes ____ No If not, why not?

11. Do you think you could blow your nose if you had to while wearing the insulating cap?

____ Yes ____ No If not, why not?

12. Did you actually try to blow your nose while wearing the insulating cap?

____ Yes ____ No If so, what happened?

13. Do you think the insulating cap can be worn comfortably with the helmets you wore today? ____ Yes ____ No Explain your answer:

14. Do you think the insulating cap and Arctic headgear can be worn comfortably with the helmets you wore today? ____ Yes ____ No Explain your answer:

15. Did the insulating cap interfere in any way with the head movements you made?

a. _____ Interfered a great deal
b. _____ Interfered a little
c. _____ Did not interfere

16. Did the insulating cap and Arctic headgear interfere with the head movements you made?

a. _____ Interfered a great deal
b. _____ Interfered a little
c. _____ Did not interfere

APPENDIX C

Frequency Tabulation of Subjects' Answers of Pre-Chamber Questionnaire

Question 1a: How clear were the instructions telling you how to put on and take off the headgear? ____ Clear ____ Unclear.
If they were not clear, why not?

One subject reported that the donning instructions for the standard headgear system was unclear. The remaining answers across both headgear conditions were that the instructions were clear.

Question 1b. I found the fit of the headgear to be

Headgear	Very Comfortable	Comfortable	Neither Comfortable Nor Uncomfortable	Uncomfortable	Very Uncomfortable
Standard	1	5	2	0	0
Experimental	2	5	0	1	0

Question 2. While you were wearing the Arctic mittens, did you have any difficulty putting on the headgear?

Headgear	Much Difficulty	Some Difficulty	No Difficulty	It was easy
Standard	0	6	1	1
Experimental	4	3	1	0

Question 3. While you were wearing the Arctic mittens, did you have any difficulty taking off the headgear?

Headgear	Much Difficulty	Some Difficulty	No Difficulty	It was easy
Standard	0	4	3	1
Experimental	1	3	4	0

Question 4. While you were wearing the wool insert mittens, did you have any difficulty putting on the headgear?

Headgear	Much Difficulty	Some Difficulty	No Difficulty	It was easy
Standard	0	3	4	1
Experimental	1	5	2	0

Question 5. While you were wearing the wool insert mittens, did you have any difficulty taking off the headgear?

Headgear	Much Difficulty	Some Difficulty	No Difficulty	It was easy
Standard	0	1	4	3
Experimental	1	3	3	1

Question 6. Did the insulating cap worn alone interfere in any way with your being able to sight with the rifle?

Headgear	Interfered a great deal	Interfered a little	Did not interfere
Standard	0	0	8
Experimental	1	1	6

Question 7. Did insulating cap and Arctic headgear interfere in any way with your being able to sight with the rifle?
Specifically, what were the problems involved?

Headgear	Interfered a great deal	Interfered a little	Did not interfere
Standard	0	4	4
Experimental	2	0	6

Question 8. Did the insulating cap interfere in any way with

a. Your being able to take water from the glass? ___ Yes ___ No
If so, describe:

One subject responded "yes" while wearing the experimental cap. All remaining responses were "no" for both headgear conditions.

b. Your being able to spit out the water? ___ Yes ___ No.
If so, describe:

All subjects responded "no" for both conditions.

c. Did the insulating cap get wet while you were drinking the water? ___ Yes ___ No

All subjects responded "no" for both conditions.

Question 9. Did the insulating cap interfere in any way with your being able to smoke? Specifically, what were the problems involved?

Headgear	Interfered a great deal	Interfered a little	Did not interfere	Did not smoke
Standard	0	0	2	6
Experimental	0	0	2	6

Question 10. Do you think you could eat if you had to while wearing the insulating cap?
____ Yes ____ No
If not, why not?

Headgear	Yes	No
Standard	8	0
Experimental	8	0

Question 11. Do you think you could blow your nose if you had to while wearing the insulating cap? ___ Yes ___ No
If not, why not?

Headgear	Yes	No
Standard	8	0
Experimental	8	0

Question 12. Did you actually try to blow your nose while wearing the insulating cap?
___ Yes ___ No
If so, what happened?

Headgear	Yes	No
Standard	1	7
Experimental	1	7

Question 13. Do you think the insulating cap can be worn comfortably with the helmets you wore today? ___Yes ___No
Explain your answer:

Headgear	Yes	No
Standard	8	0
Experimental	7	0

Question 14. Do you think the insulating cap and Arctic headgear can be worn comfortably with the helmets you wore today?

___ Yes ___ No

Explain your answer:

Headgear	Yes	No
Standard	8	0
Experimental	7	0

Question 15. Did the insulating cap interfere in any way with the head movements you made?

Headgear	Interfered a great deal	Interfered a little	Did not interfere
Standard	0	2	6
Experimental	0	3	5

Question 16. Did the insulating cap and Arctic headgear interfere with the head movements you made?

Headgear	Interfered a great deal	Interfered a little	Did not interfere
Standard	3	1	4
Experimental	0	6	2

APPENDIX D

Questionnaire — Post-Chamber Testing

Cold-Wet Environment

Name: Date:

Headgear:

PLEASE ANSWER THE FOLLOWING QUESTIONS AS THEY RELATE TO THE TIME YOU WERE IN THE ARCTIC CHAMBER **ONLY**.

1. My face was

   a. _____ Very cold
   b. _____ Cold
   c. _____ Cool
   d. _____ About the right temperature
   e. _____ Warm
   f. _____ Hot
   g. _____ Very hot

2. If you answered that your face became cold, indicate when

   a. _____ Sitting, prior to treadmill
   b. _____ While on treadmill
   c. _____ Sitting, after treadmill

   Also indicate what part of your face became cold:

3. Did frost form anywhere around your face? _____ Yes _____ No

   If so, when?

   a. _____ Sitting, prior to treadmill
   b. _____ While on the treadmill
   c. _____ Sitting, after treadmill

   Also, where did the frost form?

4. My ears were

a. _____ Very cold
b. _____ Cold
c. _____ Cool
d. _____ About the right temperature
e. _____ Warm
f. _____ Hot
g. _____ Very hot

5. If you answered that your ears became cold, indicate when:

a. _____ Sitting, prior to treadmill
b. _____ While on the treadmill
c. _____ Sitting, after treadmill

6. The back of my neck was

a. _____ Very cold
b. _____ Cold
c. _____ Cool
d. _____ About the right temperature
e. _____ Warm
f. _____ Hot
g. _____ Very hot

7. If you answered that the back of your neck became cold, indicate when:

a. _____ Sitting, prior to treadmill
b. _____ While on treadmill
c. _____ Sitting, after treadmill

8. My throat area was

a. _____ Very cold
b. _____ Cold
c. _____ Cool
d. _____ About the right temperature
e. _____ Warm
f. _____ Hot
g. _____ Very hot

9. If you answered that your throat area became cold, indicate when:

a. _____Sitting, prior to treadmill
b. _____ While on treadmill
c. _____ Sitting, after treadmill

10. The headgear felt

a. _____ Very heavy
b. _____ A little heavy
c. _____ Not heavy

11. The fit of the headgear was

a. _____Too loose
b. _____ Too tight
c. _____ Neither too tight nor too loose

12. What did you especially **like** about the headgear?

13 What did you especially **dislike** about the headgear?

14. In general, under these environmental conditions, my head was

a. _____ Very comfortable
b. _____Comfortable
c. _____ Fairly comfortable
d. _____ Neither comfortable nor uncomfortable
e. _____ Somewhat uncomfortable
f. _____ Uncomfortable
g. _____ Very uncomfortable

APPENDIX E

Final Questionnaire – Last Day

Cold-Wet Environment

Name: Date:

1. Now that you have worn both types of insulating cap, which would you rate the best?

a. _____ Cap with peak brim
b. _____ Cap without peak

Why?

2. List the reasons why you did not like the other cap as well:

APPENDIX F

Frequency Tabulation of Subjects' Answers to Post-Chamber Questionnaire: Cold-Wet Environment

Question 1. My face was

Headgear		Very Cold	Cold	Cool	About the Right Temperature	Warm	Hot	Very Hot
Standard	No Goggles	1	2	1	0	0	0	0
	Goggles	1	1	2	0	0	0	0
Experimental	No Goggles	1	0	3	0	0	0	0
	Goggles	1	1	2	0	0	0	0

Question 2. If you answered that your face became cold, indicate when:
Also indicate what part of your face became cold:

Headgear		Sitting, prior to Treadmill	While on the Treadmill	Sitting, after Treadmill
Standard	No Goggles	3	0	0
	Goggles	3	0	0
Experimental	No Goggles	1	2	1
	Goggles	2	0	0

Question 3. Did frost form anywhere around your face? ____ Yes ____ No
If so, when? Also, where did the frost form?

Headgear		Yes	No	Sitting, prior Treadmill	While on the Treadmill	Sitting, after Treadmill
Standard	No Goggles	0	4	0	0	0
	Goggles	0	4	0	0	0
Experimental	No Goggles	0	4	0	0	0
	Goggles	1	3	0	0	0

Question 4. My ears were

Headgear		Very Cold	Cold	Cool	About the Right Temperature	Warm	Hot	Very Hot
Standard	No Goggles	0	2	0	1	1	0	0
	Goggles	0	0	1	2	1	0	0
Experimental	No Goggles	0	2	1	1	0	0	0
	Goggles	0	0	1	1	2	0	0

Question 5. If you answered that your ears became cold, indicate when:

Headgear		Sitting, prior to Treadmill	While on the Treadmill	Sitting, after Treadmill
Standard	No Goggles	1	0	1
	Goggles	1	0	0
Experimental	No Goggles	2	0	1
	Goggles	0	0	0

Question 6. The back of my neck was

Headgear		Very Cold	Cold	Cool	About the Right Temperature	Warm	Hot	Very Hot
Standard	No Goggles	0	0	1	0	3	0	0
	Goggles	0	0	1	2	1	0	0
Experimental	No Goggles	0	0	2	1	1	0	0
	Goggles	0	0	1	2	1	0	0

Question 7. If you answered that the back of your neck became cold, indicate when:

Headgear		Sitting, prior to Treadmill	While on the Treadmill	Sitting, after Treadmill
Standard	No Goggles	0	0	0
	Goggles	1	0	0
Experimental	No Goggles	0	0	0
	Goggles	0	0	0

Question 8. My throat area was

Headgear		Very Cold	Cold	Cool	About the Right Temperature	Warm	Hot	Very Hot
Standard	No Goggles	0	0	2	1	1	0	0
	Goggles	0	0	1	3	0	0	0
Experimental	No Goggles	0	1	1	2	0	0	0
	Goggles	0	1	0	2	1	0	0

Question 9. If you answered that your throat area became cold, indicate when:

Headgear		Sitting, prior to Treadmill	While on the Treadmill	Sitting, after Treadmill
Standard	No Goggles	0	0	0
	Goggles	1	0	0
Experimental	No Goggles	1	0	0
	Goggles	1	0	0

Question 10. The headgear felt

All subjects indicated "not heavy" for both insulating caps.

Question 11. The fit of the headgear was

Headgear		Too Loose	Too Tight	Neither too Tight nor too Loose
Standard	No Goggles	1	0	3
	Goggles	0	1	3
Experimental	No Goggles	1	0	3
	Goggles	?	0	2

Question 12. What did you especially **like** about the headgear?

Headgear		Responses
Standard	No Goggles	Fit (2), comfortable, forehead flap, nothing
	Goggles	Warm head, not heavy (2), good fit, easy donning, no hindrance, nothing
Experimental	No Goggles	Lightweight, warm, comfortable where tight, ears warm
	Goggles	Lightweight (2), not scratchy, warm head, inside material, comfortable

Question 13. What did you especially **dislike** about the headgear?

Headgear		Responses
Standard	No Goggles	Fit, no cheek protection, nothing
	Goggles	Cold face, cold head, moist flaps, too tight
Experimental	No Goggles	Too Loose
	Goggles	One size (2), cold throat, nothing

Question 14. In general, under these environmental conditions, my head was

Headgear		Very Comfortable	Comfortable	Fairly Comfortable	Neither Comfortable nor Uncomfortable	Somewhat Uncomfortable	Uncomfortable	Very Uncomfortable
Standard	No Goggles	1	0	1	1	1	0	0
	Goggles	1	1	1	0	1	0	0
Experimental	No Goggles	0	1	1	1	1	0	0
	Goggles	1	2	1	0	0	0	0

APPENDIX G

Questionnaire: Post-Chamber Testing

Cold-Dry Environment

Name: Date:

Headgear:

Check the type of eye protection worn:

a. _____ None b. _____ Goggles

PLEASE ANSWER THE FOLLOWING QUESTIONS AS THEY RELATE TO THE TIME YOU WERE IN THE ARCTIC CHAMBER **ONLY.**

1. As a screen against the wind, the headgear was

   a. _____ Excellent
   b. _____ Good
   c. _____ Average
   d. _____ Fair
   e. _____ Poor

2. My face was

   a. _____ Very cold
   b. _____ Cold
   c. _____ Cool
   d. _____ About the right temperature
   e. _____ Warm
   f. _____ Hot
   g. _____ Very hot

3. If you answered that your face became cold, indicate when:

   a. _____ Sitting, prior to treadmill
   b. _____ While on the treadmill
   c. _____ Sitting, after treadmill

   Also, indicate what parts of your face became cold: _____

_____

_____

4. If you answered that your face became too warm, indicate when:

   a. _____ Sitting, prior to treadmill
   b. _____ While on the treadmill
   c. _____ Sitting, after treadmill

5. Did frost form anywhere around your face? ____Yes ____No

   If so, when?

   a. _____ Sitting, prior to treadmill
   b. _____ While on the treadmill
   c. _____ Sitting, after treadmill

   Also, where did the frost form?

6. My ears were

   a. _____ Very cold
   b. _____ Cold
   c. _____ Cool
   d. _____ About the right temperature
   e. _____ Warm
   f. _____ Hot
   g. _____ Very hot

7. If you answered that your ears became cold, indicate when:

   a. _____ Sitting, prior to treadmill
   b. _____ While on the treadmill
   c. _____ Sitting, after treadmill

8. The back of may neck was

   a. _____ Very cold
   b. _____ Cold
   c. _____ Cool
   d. _____ About the right temperature
   e. _____ Warm
   f. _____ Hot
   g. _____ Very hot

9. If you answered that the back of your neck became cold, indicate when:

   a. _____ Sitting, prior to treadmill
   b. _____ While on the treadmill
   c. _____ Sitting, after treadmill

10. My throat was

   a. _____ Very cold
   b. _____ Cold
   c. _____ Cool
   d. _____ About the right temperature
   e. _____ Warm
   f. _____ Hot
   g. _____ Very hot

11. If you answered that your throat area became cold, indicate when:

   a. _____ Sitting, prior to treadmill
   b. _____ While on the treadmill
   c. _____ Sitting, after treadmill

12. During the time you wore the headgear in the cold, did your face become wet?
   _____Yes _____No

13. The headgear felt

   a. _____ Very heavy
   b. _____ A little heavy
   c. _____ Not heavy

14. If you wore a face covering today, did the stiffener under the eye holes bother you in any way?

   a. _____ Bothered me a lot
   b. _____ Bothered me a little
   c. _____ Did not bother me
   d. _____ Did not wear a face covering

IF YOU WORE GOGGLES, ANSWER QUESTIONS 15, 16, AND 17

15. Did your goggles fog?

a. _____ Did not fog up at all
b. _____ Some portions fogged up
c. _____ All portions fogged up

16. If your goggles fogged, indicate when they began fogging:

a. _____ Sitting, prior to treadmill
b. _____ While on treadmill
c. _____ Sitting, after treadmill

17. Should the goggles you wore today be worn with the headgear?

____Yes ____ No Explain your answer:

18. If you had any difficulty breathing through the part of the headgear that covered your nose and mouth, indicate when:

a. _____ Sitting, prior to treadmill
b. _____ While you were on the treadmill
c. _____ Sitting, after the treadmill

19. Did the part of the headgear that covered your nose and mouth ever become wet?
____Yes ____ No If so, when?

a. _____ Sitting, prior to treadmill
b. _____ While on the treadmill
c. _____ Sitting, after the treadmill

20. Did the part of the headgear that covered your nose and mouth ever freeze?
____Yes ____No If so, when?

a. _____ Sitting, prior to treadmill
b. _____ While on treadmill
c. _____ Sitting, after the treadmill

21. The amount of frost forming on the part of the headgear covering the nose and mouth was

a. _____ None
b. _____ A little
c. _____ Some
d. _____ A lot

22. How often was it necessary to shed any frost on the part of the headgear covering your nose and mouth?

a. _____ Very often (once every five minutes or less)
b. _____ Often (once every five to ten minutes)
c. _____ Occasionally (once every ten to twenty minutes)
d. _____ Seldom (once or twice)
e. _____ Never

23. The frost which formed on the part of the headgear covering the nose and mouth

a. _____ Was difficult to shed and caused significant discomfort
b. _____ Was difficult to shed but caused little or no discomfort
c. _____ Was easy to shed but caused significant discomfort
d. _____ Was easy to shed and caused little or no discomfort
e. _____ No frost formed

24. Did the headgear covering your nose and mouth have any adverse effects on your face or skin (e.g., rash or bruise)?

____Yes ____No If so, what happened?

25. What did you especially **like** about the headgear?

26. What did you especially **dislike** about the headgear?

27. In general, under these environmental conditions, my head was

a. _____ Very comfortable
b. _____ Comfortable
c. _____ Fairly comfortable
d. _____ Neither comfortable nor uncomfortable
e. _____ Somewhat uncomfortable
f. _____ Uncomfortable
g. _____ Very uncomfortable

APPENDIX H

Final Questionnaire – Last Day

Cold-Dry Environment

Name: Date:

1. Now that you have worn all three types of headgear, which would you rate the best?

a. ____ Insulating cap, hood, and fur ruff
b. ____ Insulating cap, neck cover, and face cover
c. ____ Insulating cap, hood, fur ruff, and face mask

Why?

2. Which would you rate the second best?

a. ____ Insulating cap, hood, and fur ruff
b. ____ Insulating cap, neck cover, and face cover
c. ____ Insulating cap, hood, fur ruff, and face mask

Why?

3. Which would you rate as the poorest?

a. ____ Insulating cap, hood, and fur ruff
b. ____ Insulating cap, neck cover, and face cover
c. ____ Insulating cap, hood, fur ruff, and face mask

Why?

APPENDIX I

Frequency Tabulation of Subjects' Answers to Post-Chamber Questionnaire: Cold-Dry Environment

Question 1. As a screen against the wind, the headgear was

Headgear		Excellent	Good	Average	Fair	Poor
STD	No Goggles	1	1	1	1	0
	Goggles	3	1	0	0	0
STD/M	No Goggles	0	2	0	2	0
	Goggles	4	0	0	0	0
EXPER	No Goggles	0	2	1	1	0
	Goggles	0	2	1	0	1

Question 2. My face was

Headgear		Very Cold	Cold	Cool	About the right Temperature	Warm	Hot	Very Hot
STD	No Goggles	0	3	0	1	0	0	0
	Goggles	2	0	0	1	1	0	0
STD/M	No Goggles	0	1	0	2	1	0	0
	Goggles	0	0	0	0	2	2	0
EXPER	No Goggles	0	2	2	0	0	0	0
	Goggles	2	1	1	0	0	0	0

Question 3. If you answered that your face became cold, indicate when:

Headgear		Sitting, prior to Treadmill	While on the Treadmill	Sitting, after Treadmill
STD	No Goggles	1	1	1
	Goggles	2	0	0
STD/M	No Goggles	0	0	1
	Goggles	0	0	0
EXPER	No Goggles	1	1	0
	Goggles	2	1	0

Question 4. If you answered that your face became too warm, indicate when:

Headgear			Sitting, prior to Treadmill	While on the Treadmill	Sitting, after Treadmill
STD	No	Goggles	0	0	0
		Goggles	0	0	0
STD/M	No	Goggles	1	0	0
		Goggles	2	1	0
EXPER	No	Goggles	0	0	0
		Goggles	0	0	0

Question 5. Did frost form anywhere around your face?
___ Yes _____No If so, when?

Headgear			Yes	No	Sitting, prior to Treadmill	While on the Treadmill	Sitting, after Treadmill
STD	No	Goggles	2	2	2	0	0
		Goggles	3	1	2	0	1
STD/M	No	Goggles	1	3	0	0	1
		Goggles	2	2	2	0	0
EXPER	No	Goggles	4	0	4	0	0
		Goggles	4	0	2	1	0

Question 6. My ears were

Headgear			Very Cold	Cold	Cool	About the right Temperature	Warm	Hot	Very Hot
STD	No	Goggles	0	0	1	2	1	0	0
		Goggles	0	0	0	2	2	0	0
STD/M	No	Goggles	0	0	1	2	1	0	0
		Goggles	0	0	0	0	3	1	0
EXPER	No	Goggles	0	0	1	1	2	0	0
		Goggles	0	1	1	1	1	0	0

Question 7. If you answered that your ears became cold, indicate when: One subject wearing experimental headgear with eyecover indicated "sitting", after treadmill".

Question 8. The back of my neck was

Headgear		Very Cold	Cold	Cool	About the right Temperature	Warm	Hot	Very Hot
STD	No Goggles	0	0	2	1	1	0	0
	Goggles	0	0	0	3	1	0	0
STD/M	No Goggles	0	0	2	1	1	0	0
	Goggles	0	0	0	0	4	0	0
EXPER	No Goggles	0	0	1	1	2	0	0
	Goggles	0	0	0	2	2	0	0

Question 9. If you answered that the back of your neck became cold, indicate when: The only response was "sitting, prior to treadmill" from one subject wearing the standard headgear without eyecover.

Question 10. My throat area was

Headgear		Very Cold	Cold	Cool	About the right Temperature	Warm	Hot	Very Hot
STD	No Goggles	0	0	0	4	0	0	0
	Goggles	0	0	0	3	1	0	0
STD/M	No Goggles	0	0	2	2	0	0	0
	Goggles	0	0	0	0	4	0	0
EXPER	No Goggles	0	0	1	2	1	0	0
	Goggles	1	0	0	2	1	0	0

Question 11. If you answered that your throat became cold, indicate when: One subject wearing experimental headgear with eyecover indicated "sitting, prior to treadmill".

Question 12. During the time you wore the headgear in the cold, did your face become wet?

____ Yes ____ No

Headgear			Yes	No
STD	No	Goggles	2	2
		Goggles	1	3
STD/M	No	Goggles	1	3
		Goggles	2	2
EXPER	No	Goggles	3	1
		Goggles	4	0

Question 13. The headgear felt

Headgear			Very heavy	A little heavy	Not heavy
STD	No	Goggles	0	2	2
		Goggles	0	1	3
STD/M	No	Goggles	0	2	2
		Goggles	0	1	3
EXPER	No	Goggles	0	1	3
		Goggles	0	0	4

Question 14. If you wore a face covering today, did the stiffener under the eyeholes bother you in any way?

Headgear			Bothered me a lot	Bothered me a little	Did not bother me	Did not wear a face covering
STD/M	No	Goggles	0	2	2	0
		Goggles	0	1	3	0
EXPER	No	Goggles	1	0	2	0
		Goggles	0	0	2	1

Question 15. Did your goggles fog?

Headgear	Did not fog up at all	Some portions fogged up	All portions fogged up
STD	0	2	2
STD/M	0	1	3
EXPER	1	0	3

Question 16. If your goggles fogged, indicate when they began fogging.

Headgear	Sitting, prior to Treadmill	While on Treadmill	Sitting, after Treadmill
STD	4	0	0
STD/M	4	0	0
EXPER	2	1	0

Question 17. Should the goggles you wore today be worn with the headgear?
____ Yes ____ No Explain your answer:

Headgear	Yes	No
STD	2	2
STD/M	2	2
EXPER	3	1

Question 18. If you had any difficulty breathing through the part of the headgear that covered your nose and mouth, indicate when:

Headgear		Sitting, prior to Treadmill	While on Treadmill	Sitting, after Treadmill
STD	No Goggles	0	0	0
	Goggles	1	0	0
STD/M	No Goggles	1	2	0
	Goggles	1	0	1
EXPER	No Goggles	0	0	0
	Goggles	0	0	0

Question 19. Did the part of the headgear that covered your nose and mouth ever become wet?
____. Yes ____ No If so, when?

Headgear		Yes	No	Sitting, prior to Treadmill	While on Treadmill	Sitting, after Treadmill
STD	No Goggles	3	0	2	1	0
	Goggles	2	1	2	0	0
STD/M	No Goggles	2	2	1	1	0
	Goggles	2	2	1	1	0
EXPER	No Goggles	3	1	2	0	0
	Goggles	4	0	3	0	1

Question 20. Did the part of the headgear that covered your nose and mouth ever freeze?

____ Yes ____ No If so, when?

Headgear			Yes	No	Sitting, prior to Treadmill	While on Treadmill	Sitting, after Treadmill
STD	No	Goggles	2	1	1	0	0
		Goggles	0	3	0	0	0
STD/M	No	Goggles	0	4	0	0	0
		Goggles	0	4	0	0	0
EXPER	No	Goggles	1	3	1	0	0
		Goggles	3	1	1	1	1

Question 21. The amount of frost forming on the part of the headgear covering the nose and mouth was

Headgear			None	A little	Some	A lot
STD	No	Goggles	0	3	0	0
		Goggles	2	1	0	0
STD/M	No	Goggles	0	2	0	1
		Goggles	3	1	0	0
EXPER	No	Goggles	0	0	3	0
		Goggles	0	1	0	3

Question 22. How often was it necessary to shed any frost on the part of the headgear covering your nose and mouth?

Headgear			Very often (5 min or less)	Often (5-10 min)	Occasionally (10-20 min)	Seldom (once or twice)	Never
STD	No	Goggles	0	0	1	2	0
		Goggles	0	0	0	1	2
STD/M	No	Goggles	1	0	2	1	0
		Goggles	0	0	0	0	4
EXPER	No	Goggles	0	0	0	3	1
		Goggles	1	0	1	0	2

Question 23. The frost which formed on the part of the headgear covering the nose and mouth

		Difficult to shed significant discomfort	Difficult to shed little or no discomfort	Easy to shed significant discomfort	Easy to shed little or no discomfort	No frost formed
STD	No Goggles	0	0	0	3	0
	Goggles	0	0	0	1	2
STD/M	No Goggles	1	0	0	2	0
	Goggles	0	0	0	1	3
EXPER	No Goggles	0	0	1	2	0
	Goggles	3	0	0	0	0

Question 24. Did the headgear covering your nose and mouth have any adverse effects on your face or skin (e.g., rash or bruise)?

_____ Yes _____ No

If so, what happened? Only one subject responded "yes". He was wearing the experimental headgear without eyecover and reported a rash on the right cheek.

Question 25. What did you especially **like** about the headgear?

Headgear		Responses
STD	No Goggles	Warm, comfortable
	Goggles	Warm, shaped hood, goggles okay
STD/M	No Goggles	Lots of protection, no comment
	Goggles	Face warm, does not freeze up, warm (3), outstanding, stops wind
EXPER	No Goggles	Lightweight, warm, no interference, comfortable, better vision
	Goggles	Lightweight, warm in some areas (2), comfortable, nothing

Question 26. What did you especially **dislike** about the headgear?

Headgear		Responses
STD	No Goggles	Poor visibility, didn't cover nose
	Goggles	Didn't cover face well (2), too cold (2), nothing
STD/M	No Goggles	Hard breathing, cool back of head
	Goggles	Heavy, claustrophobic, blocked vision, frosted goggles, oronasal portion, nothing
EXPER	No Goggles	Forehead uncovered, cold air leaked at eyes, nothing
	Goggles	Too big, fit, too many air leaks, chin and left side of face cold, cold, uncomfortable

Question 27. In general, under these environmental conditions, my head was

Headgear		Very Comfortable	Comfortable	Fairly Comfortable	Neither Comfortable Nor Uncomfortable	Somewhat Uncomfortable	Uncomfortable	Very Uncomfortable
STD	No Goggles	0	1	1	1	1	0	0
	Goggles	1	0	0	1	1	0	0
STD/M	No Goggles	0	2	1	0	0	0	1
	Goggles	4	0	0	0	0	0	0
EXPER	No Goggles	1	0	2	0	0	1	0
	Goggles	1	0	0	1	0	0	2